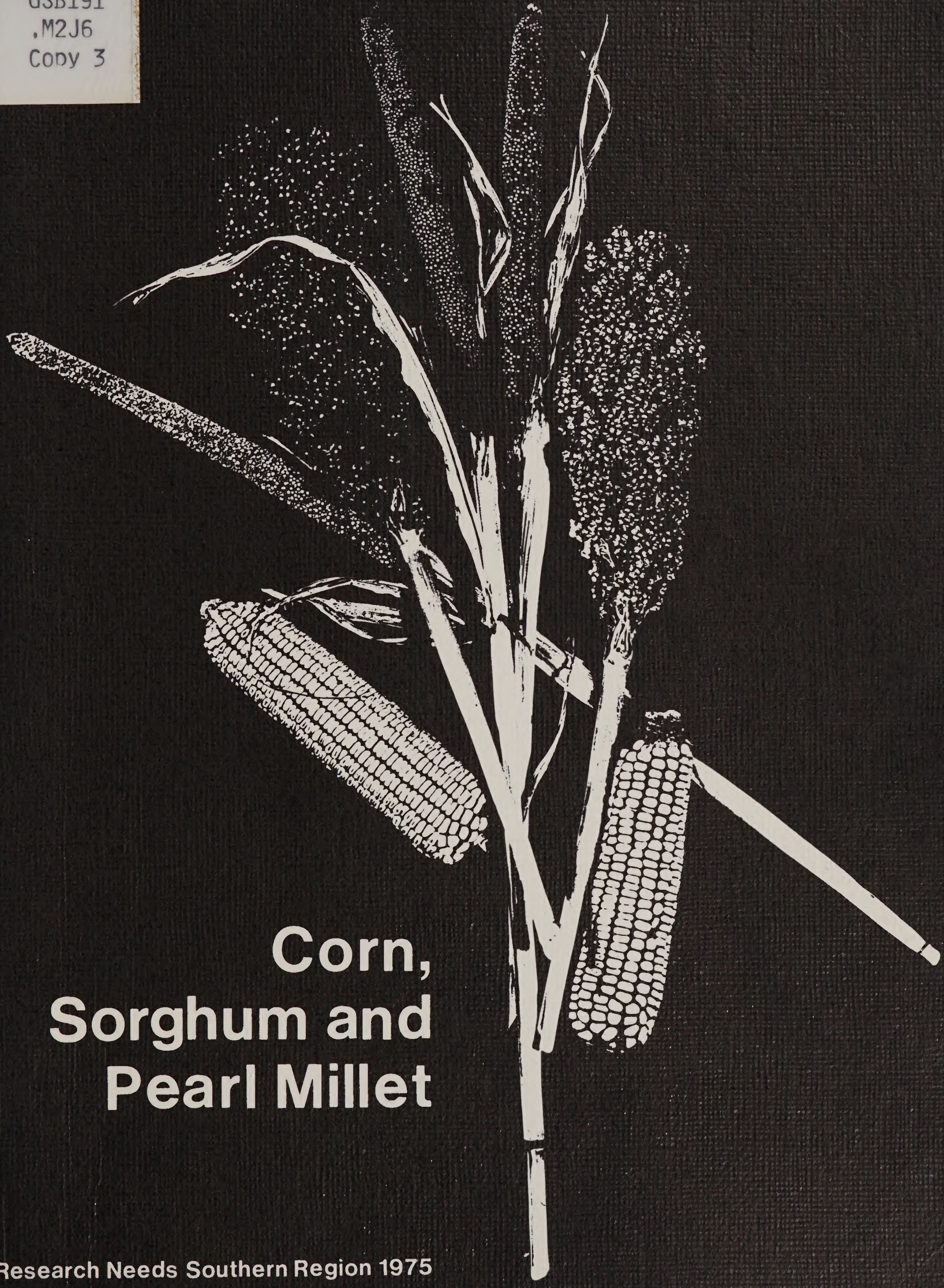

Corn, Sorghum and Pearl Millet

Research Needs Southern Region 1975

CORN, SORGHUM AND

PEARL MILLET

Research Needs

Southern Region

1975

Prepared by:

A Joint Task Force of the Southern Region Agricultural Experiment Stations and United States Department of Agricultural research scientists.

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FOREWORD

Authority: The Southern Regional Task Force on Corn, Sorghum and Pearl Millet was appointed in the spring of 1974 by the Experiment Station Directors and the USDA-ARS of the Southern Region following an agreement between the National Association of State Universities and Land-Grant Colleges and the U. S. Secretary of Agriculture to enter into joint planning of agricultural research.

Mission: The mission of the Task Force shall be to evaluate the research program on corn, sorghum and pearl millet in the Southern Region and make recommendations on the needs and adjustments needed to make the maximum contribution to society and the industry.

Procedure:

1. Identify the major problems and improvement opportunities.

2. Evaluate adequacy of present research

3. Recommend shifts in existing resource allocations to meet the needs now and in the future.

4. Suggest priorities.

Acknowledgement: This Task Force relied heavily upon recommendations presented in "A National Program of Research for Corn and Grain Sorghum" prepared in 1969 by a Joint Task Force of the US Department of Agriculture, and the State Universities and Land Grant Colleges.

CORN, SORGHUM AND PEARL MILLET

RESEARCH NEEDS - SOUTHERN REGION 1975

INTRODUCTION

The United States of America and world food demands have increased in recent years and are expected to continue to do so in the future. To satisfy the demands it will be necessary to apply all available technology and to develop improved plants, animals and methods.

Research on corn, sorghum and pearl millet should be increased and made more effective in order to develop these crops to their optimum. As important as these crops are in the Southern Region their potentials are even greater. Corn, sorghum and pearl millet were valued at over $2.2 billion in the Southern Region in 1973. Livestock and poultry industries have flourished in the last decade with increasing amounts of available grain. Research opportunities exist which will further increase grain and forage production for these crops.

The Corn, Sorghum and Pearl Millet Task Force has identified goals and potentials for the future and presents here the research activities, support, and scientists needed to achieve these goals. Implementation of the suggestions of this Task Force should result in more effective research programs and increased agricultural productivity. This will result in helping meet the U. S. and world food needs in future years.

Importance of Crops in Southern Region

In the Southern Region, consisting of 13 states, Puerto Rico and the Virgin Islands, corn, sorghum and pearl millet are each adapted to specific environmental conditions. Corn is grown in the higher rainfall and irrigated areas. Sorghum is better adapted to some of the areas with limited rainfall, especially in the western part of the region. It is also grown in humid areas and responds to irrigation. Pearl millet has a wide area of adaptation, and has become particularly popular in the drier, sandy areas of the Southeast because of its drought tolerance.

In 1973 the Southern Region had about 18.4 million acres of corn and sorghum, 15.5 million acres of which were for grain; the rest were used for silage and forage (Table 1). No official production figures are available for pearl millet but it is estimated that there are more than one million acres planted to this crop. In the U. S. pearl millet is used almost entirely for grazing, but it is of potential importance for grain and silage in areas of uncertain rainfall. Corn and sorghum production in the Southern Region are roughly equal. One-half of the nation's sorghum is grown in the Southern States, principally in Texas and Oklahoma (Tables 1 and 2).

A comparison with other crops of the Southern Region helps place in perspective the importance of these feed-grain crops. In 1973, the corn and sorghum grain on 18.4 million acres was valued at $2.2 billion

Table 1. Production of Corn, Sorghum and Pearl Millet in the Southern Region, 1973[1].

	Acres		Bu.	Value, Dollars
	1000		1000	1000
Corn				
Grain	7,479		504,735	$1,233,247
Silage	969			
Forage	185			
Total		8,633		
Sorghum				
Grain	8,077		467,191	$ 984,515
Silage	301			
Forage	1,436			
Total		9,814		
Pearl Millet		1,000[2]		
TOTAL		19,447	971,926	$2,217,762

[1] Compiled from USDA Crop Reporting Service, Annual Summary, January 1974.

[2] Estimate, no figures available.

(Table 1) which approaches the $2.5 billion value of cotton (lint plus seed) harvested from 10.4 million acres in the Southern Region. The corn and sorghum value does not include silage and forage for which value figures are not available. Production of corn and sorghum by Southern Region states is presented in Table 2.

In evaluating the importance of these feed grains, silage and forages one must recognize that a large quantity is used for livestock and poultry feed, and thus contribute greatly to other aspects of the agricultural economy. For example in the U. S. 76 percent of the broilers and 31 percent of the cattle are produced in the Southern Region. If more grain were available, livestock and poultry production would increase in the Southern Region. The increased sorghum production in Texas in recent years has been a major factor in increased beef production, helping to make it the leading cattle-feeding state in the nation. At present the Southeast is a grain-deficit area and could benefit from increased grain production.

Table 2. Acres of Corn and Sorghum in each State of the Southern Region, 1973[1].

State	Corn			
	Grain	Silage	Forage	Total
	1000	1000	1000	1000
Alabama	610	42	35	687
Arkansas	21	10	2	33
Florida	340	13	37	390
Georgia	1,670	90	36	1,796
Kentucky	1,010	130	10	1,150
Louisiana	65	12	2	79
Mississippi	148	43	5	196
North Carolina	1,400	120	20	1,540
Oklahoma	87	31	3	121
South Carolina	430	45	15	490
Tennessee	508	161	9	678
Texas	640	96	7	743
Virginia	550	176	4	730
TOTAL	7,479	969	185	8,633
	Sorghum			
Alabama	31	12	19	62
Arkansas	149	25	11	185
Florida	--	--	--	--
Georgia	34	17	7	58
Kentucky	17	8	4	29
Louisiana	26	8	4	38
Mississippi	30	44	10	84
North Carolina	82	26	10	118
Oklahoma	696	56	343	1,095
South Carolina	15	11	3	29
Tennessee	33	16	10	59
Texas	6,950	65	1,012	8,027
Virginia	14	13	3	30
TOTAL	8,077	301	1,436	9,814

[1] Compiled from USDA Crop Reporting Service, Annual Summary, January 1974.

No figures were available for Puerto Rico or the Virgin Islands nor for pearl millet.

Status of Research

Cooperation of state agricultural experiment stations and USDA-ARS has characterized the research efforts with corn, sorghum and millet since the beginning of public-supported research on these crops. At most locations state and federal employees have worked as teams to solve the pressing problems. Probably the most important ingredient in the success of this research has been the unity and singleness of purpose of state and federal personnel.

In all three crops F_1 hybrids are grown almost exclusively. Increased acreages, yields per acre and improved quality were direct results. Commercial seed industries also developed and increased with the advent of hybrids. The successes with hybrids and associated practices have brought increasing demands for additional research. More intensified production and cultural problems have brought a greater urgency for solution.

In the Southern Region there are about 100 scientific man years (SMY) among state and federal workers assigned to research on these crops (Table 3); 73 are assigned to corn (50 state and 23 ARS) and 23 to sorghum (18 state and 5 ARS). Although no researchers are officially assigned to pearl millet, about 1.5 SMY in Georgia are estimated to be devoted to this crop. Approximately 90 percent of the total research effort is directed toward production problems. The balance is concerned with utilization and marketing.

Table 3. Allocation of Scientific Man Years (SMY's) to Research Problem Areas (RPA's) to Corn, Sorghum and Pearl Millet in the Southern Region.

RPA		SMY Allocation 1973	10% Total Increase	10 yr. Need
207	Insects	22.7	23.7[1]	34[1]
208	Diseases	18.2	22.2[1]	32[1]
209	Weeds	4.1	6.1[1]	10[1]
307	Biological efficiency	38.0	40.0[1]	60[1]
308	Mechanization	2.4	2.4	4[1]
309	Management Systems	2.2	3.2[1]	8[1]
405	Product acceptability	2.5	2.5	5[1]
406	Food products	1.7	1.7	3[1]
407	Feed and industrial products	1.1	1.1	2[1]
408	Storage and marketing	2.3	2.3	4[1]
503	Marketing efficiency	0.8	0.8	2[1]
Total		96.0	106.0[1]	164[1]

[1] Change from 1973 allocation.

Purpose and Procedure of Task Force

The Corn, Sorghum and Pearl Millet Task Force of the Southern Region was established in the spring of 1974. Research potentials were viewed in light of an increasing capacity for multidisciplinary research to solve specific problems. Task Force members most familiar with each Research Problem Area (RPA) developed statements of research needs. Assistance from others was sought for those activities for which expertise did not exist among the members of the Task Force. The report of a National Task Force on Corn and Grain Sorghum published in 1969 (A National Program of Research for Corn and Grain Sorghum) was used as a guide for considerations and presentation of research needs by the current Southern Region Task Force.

Projected Research and Allocation of Scientists

Although much capable research is being performed on corn, sorghum and pearl millet, more is needed to capitalize on the potentials of these crops in the Southern Region. Much of the research in progress is directed to current needs but there should be a continual updating of priorities, examination of problems and reallocation of funds if necessary. In the consideration of needs, applied research directed to immediate problems should be balanced with basic research which provides the groundwork for applied research of the future.

Corn and sorghum research is not restricted to the Southern Region, and our research should be coordinated with that of other regions. Programs of research on national and international goals must be maintained through cooperative and individual efforts.

Scientists working with corn, sorghum and pearl millet are now for the most part inadequately supported in relation to the importance of these crops to the Southern Region. The most urgent resource needed is more financial and technical support for ongoing research, thereby making most efficient use of present scientific manpower. It is anticipated that additional support to areas of high priority could result in a manifold increase in applicable research results (Table 3).

It is not possible to highlight all of the research of present or potential significance but some examples will illustrate the needs and potentials. As these crops are more intensively grown, disease and insect pests will become increasing problems. Present staffing and support is inadequate to meet the management research needed in these areas. Diseases and insects are particularly troublesome in the South because of the warm, humid climate. Some of the research on pests in the Southern Region is conducted so as to solve problems, such as sorghum downy mildew, that are of potential importance to other regions.

Studies of drought tolerance and water-use efficiency could improve the adaptation of these crops to marginal areas and help stabilize production in years of limited rainfall. In addition, such studies could help make more efficient use of present finite water supplies.

Genetic vulnerability of corn, sorghum and pearl millet has been recognized as a serious problem because of the tendency toward uniform planting of single or related hybrids and varieties throughout extensive areas. Diverse germplasm is available but new systems for introducing and utilizing diversity need to be developed and tested.

The increasingly important role of the Mayaguez Institute for Tropical Agriculture in Puerto Rico is recognized. Considerations need to be given to cooperative state-ARS and inter-regional arrangements to most efficiently utilize the Puerto Rico station. It has potential for greater utilization as a winter nursery, for converting tropical lines to temperate adaptation, for changing temperate lines to tropical adaptation, and as the supervisory center for introducing material under quarantine. Cooperation should be strengthened with programs in other countries and with international programs such as International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India and International Maize and Wheat Improvement Center (CIMMYT) in Mexico.

Cooperative research with private interests should be maintained and strengthened. Hybrids are used in each of these crops and private companies have considerable scientific input.

Realizing that there is an increasing demand for the direct consumption of cereals by humans, more consideration needs to be given to the food properties of the grains of these three crops. Each of them is now utilized as human food in many parts of the world and diversity of food characteristics is recognized within each of these crops.

As our society evolves, so must agriculture change to meet the demands. Changes in the availability of energy, land, and water dictate that agricultural research find ways for more efficient use of these resources. Changes in cultural methods, crops grown, varieties used, etc. will be necessary.

Implementation of the recommendations of this Task Force should result in more intensified and balanced research programs on corn, sorghum and pearl millet in the Southern Region. It would more clearly focus research on the problems recognized by the Task Force as being of present and future importance.

The long range results of these new research efforts should be more efficient and dependable production of these crops. Such would contribute to increasing stability for agriculture and related industries and accompanying food stability for consumers.

The research problem areas and their priorities are shown in Table 4 while a summary of the present and recommended SMY's for each RPA may be found at the end of the report.

Table 4. Research Problem Areas (RPA's) and Priorities.

No.	Title	Priority
RPA 207	Control of Insects, Mites, Snails, and Slugs	
207-A	Host plant resistance	1
207-B	Economic injury levels	1
207-C	Biological control	2
207-D	Biology, taxonomy, physiology, and nutrition	2
207-E	Cultural practices	3
207-F	Non-insecticidal manipulators (attractants etc.)	2
207-G	Insecticidal control	4
RPA 208	Control of Diseases and Nematodes	
208-A	Identification, etiology, and development of diseases	1
208-B	Genetics of plant-pathogen interactions and control of disease through genetics and breeding	1
208-C	Nature and mechanism of disease resistance	1
208-D	Control of disease through the use of pesticides and management practices	2
208-E	Storage diseases and relationship of disease to quality	3
RPA 209	Control of Weeds and Other Hazards	
209-A	Develop management systems involving combinations of weed control practices	1
209-B	Improved equipment for herbicide applications and physical methods of weed control	1
209-C	Improve the effectiveness and safety of current herbicides	1
209-D	Control of weeds by biological means	2
209-E	Comparative biology, physiology, and ecology of specific weeds and crops	2
209-F	Mechanism of herbicide action and physiological-environmental interactions of herbicide effects	2
209-G	Evaluation of new herbicides	3
209-H	Techniques for repelling and excluding bird and mammal pests	3
RPA 307	Improvement of Biological Efficiency	
307-A	Application of physiological, molecular, and quantitative genetic principles to breeding	1
307-B	Reduce genetic vulnerability and facilitate genetic improvement by the collection, evaluation, and maintenance of germplasm	1
307-C	Development of plant nutrient requirements and cultural practices so as to maximize production and minimize environmental pollution	1
307-D	Genetic and cytogenetic studies on control of biological processes	2
307-E	Efficiency of solar energy conversion to grain and forage	2
307-F	Fundamental studies of physiological and metabolical plant processes and their inheritance	3
307-G	Improvements in efficiency of water utilization	3

Table 4. (Continued)

No.	Title	Priority
RPA 308	Mechanization of Production	
308-A	Mechanization of production	1
308-B	Equipment and methods for harvesting, drying, and storage	2
RPA 309	Production Management Systems	
309-A	Optimizing production systems	1
309-B	Evaluation of emerging technology	2
309-C	Farm and regional equilibria	3
RPA 405	Production of Crops with Improved Acceptability	1
RPA 406	New and Improved Food Products	2
RPA 407	New and Improved Feed and Industrial Products	
407-A	Development of feed products having increased palatability and nutritional quality for livestock	1
407-B	Discovery and development of new chemical products from corn, sorghum and perhaps pearl millet starches and flours for use in large-volume industrial applications	2
407-C	Conversion of corn and sorghum starches and flours into improved internal and surface-sizing agents, wet-strength agents, and adhesives for the paper industry	3
RPA 408	Quality Maintenance in Storing and Marketing	
408-A	Detecting and measuring quality factors	1
408-B	Maintaining quality during storage, processing, and transport	1
RPA 503	Efficiency in Marketing Agricultural Products	
503-A	Development and evaluation of improved methods, equipment, and systems for handling grain in the marketing channels	1
503-B	Analysis of economic structure, behavior, and performance in markets	2

RPA 207

CONTROL OF INSECTS, MITES, SNAILS AND SLUGS

INTRODUCTION

Corn and sorghum are major crops which are produced in monocultures under widely different environmental conditions. Many interrelated problems result in which insects are commonly involved. Many species of insects cause direct damage to corn, sorghums and millet each year in the Southern United States as either key, secondary or occasional pests. Others cause indirect damage by transmitting diseases or stressing plants to the point of susceptibility to disease. Additional major pests which can be accidentally introduced at any time attack these crops elsewhere in the world.

The introduction and use of organic insecticides in the last two decades and the development of better equipment for applying them have been important factors in the control of corn, sorghum and millet insects. However, the continued opposition to the use of insecticides plus the realization of the unreliability of a total dependence on insecticides for insect control has led to the need for reevaluation of pest control techniques. Total dependence on insecticides to control pests has led to such problems as insecticide resistance, pest resurgence, secondary pest outbreaks, environmental and health hazards, and disruption of insect populations in nontarget crops in the ecosystem.

The need to investigate all possible means for control of destructive insects must be emphasized. Although many of the benefits of research to develop more effective, integrated control systems cannot be quantified specifically, the development of management systems utilizing all applicable methods of pest suppression in a compatible ecologically sound manner would reduce the need for insecticides. The reduction of hazards to benficial insects and wildlife, and reduction of air, food, soil and water pollution would also be accomplished. Benefits from the development of such management systems cannot be expressed in dollars. The knowledge gained from the research outlined as components of a management system under RPA 207 would reduce the cost of production and maintain or increase yield and quality of corn, sorghum and millet.

TITLE: Host plant resistance. RPA 207-A

SMY:

	Number
Current	5.7
10% increase	6.0
Recommended	7.5

PRIORITY: 1

SITUATION EVALUATION: One of the most economical and desirable ways to reduce insect damage to crops is through the use of resistant germplasm. Resistance can be combined with other desirable qualities and reduce damage without direct cost to the grower and without creating insecticidal problems which may upset nature's balance between pest insects and their natural enemies. Progress has been made in developing corn and sorghum inbreds and hybrids which are resistant to several insects. Breeding programs need to provide a continuous supply of resistant germplasm since insect strains often develop which will attack inbreds or hybrids now classified as resistant.

Information on new sources of resistance and on methods of breeding and producing resistant inbreds and hybrids are required so that resistant hybrids can be produced more rapidly and efficiently. Resistant hybrids should be a part of the integrated control methods, since hybrids with only a moderate degree of resistance can be used to supplement biological, cultural, chemical, or other control methods. Possibly half of the annual insect loss to corn, sorghum and millet could be prevented if hybrids resistant to the major insects could be developed.

OBJECTIVE: To identify and evaluate the insect resistance of corn, sorghum and millet germplasm from various sources, and determine the mechanisms of such resistance.

RESEARCH APPROACHES:

A. Evaluate corn, sorghum and millet germplasm including exotic varieties and wild relatives for resistance to major insects.

B. Develop improved methods for producing insects for use in manual infestations to determine the relative resistance of corn, sorghum and millet germplasm.

C. Determine the chemical, physiological or morphological nature of resistance.

D. Determine the presence and the relative abundance of different physiological races of insects before and after resistant hybrids have been released.

E. Determine the effect of resistant hybrids on the overall population of the insect in the area.

F. Determine degree of resistance that is economically satisfactory.

G. Determine the factors responsible for development of insect biotypes which react differently to resistant varieties.

H. Determine the value of low levels of insect resistance when combined with chemical or other control methods.

I. Determine the effect of insect resistance on the parasites and predators of the insect pest involved.

J. Determine the effect of environmental factors on resistance.

K. Coordinate findings with RPA 207-E, 208-B, 307-D and 405.

TITLE: Economic injury levels. RPA 207-B

SMY:

	Number
Current	2.0
10% increase	2.5
Recommended	4.5

PRIORITY: 1

SITUATION EVALUATION: One of the major components of a pest management strategy is the economic injury level or the population levels of insects that are required to warrant control measures which will prevent a net loss in crop value. A knowledge of this level is required in order to make judgment decisions as to when other components of the management system have failed. Artificial suppression methods are required to prevent further crop loss. Without a thorough knowledge of pest population levels and population dynamics there is often a complete reliance on prophylactic treatment schedules because of the uncertainty involved.

At the other extreme, damaging numbers of a pest may increase beyond the economic threshold and crop yields can be markedly reduced because pesticides are not used. An important aspect of integrated pest control is to bring a better balance between these two extremes to achieve a more scientific approach to the control of pest populations. A knowledge of the economic injury level will save money for producers who do not need to spray, as well as for producers who need to spray for control to prevent further yield loss.

OBJECTIVE: To determine the economic injury level of pests of corn, sorghum and millet relating insect population density and plant damage to yield loss.

RESEARCH APPROACHES:

A. Determine the effect of various insect populations at different times and under different growing conditions on yield and quality of corn, sorghums and millet and determine the economic threshold.

B. Use genetically similar resistant and susceptible host strains (isogenic lines) or chemical control to determine extent and type of plant injury by insects.

C. Determine the economic impact of major pests of the crops within geographical areas.

D. Determine the influence of pest populations on other factors affecting crop yield, such as disease.

E. Determine factors influencing plant stress that may cause the insect economic injury level to vary because of the health condition of the plants.

F. Determine the rate of increase of pests in order to determine the economic threshold level.

G. Coordinate with RPA 307-C and 309.

TITLE: Biological control. RPA 207-C

SMY:

	Number
Current	5.0
10% increase	5.0
Recommended	7.0

PRIORITY: 2

SITUATION EVALUATION: Biological factors such as parasites, predators, and diseases often play a major role in reducing insect populations. Some of our most injurious insects on corn, sorghum and millet have been accidentally introduced from foreign countries. The increased world trade and travel make it almost impossible to prevent additional accidental introductions. Since introduced pests usually arrive without their natural enemies, some that were of little economic importance in their native habitat have become very destructive in their new environment. There is need to collect, propagate, and introduce parasites, predators and insect pathogens from the insect's native home and disseminate them throughout the range of the pest.

Many injurious insects on corn, sorghum and millet have a variety of native parasites and predators, attacking them throughout their seasonal history. Some of these appear to be quite effective. However, little is known about the biology and ecology of these control agents and the factors which affect their abundance.

There is need to thoroughly survey the parasites and predators of corn, sorghum, and millet insects and determine which ones exhibit potential as effective control agents. For those agents which do exhibit

potential use, subsequent biological and ecological studies in the laboratory and field should be conducted to determine how they might be best utilized and applied in the pest management program. A slight ecological manipulation may be all that is required to throw conditions in favor of the natural enemy. In other instances, it may be feasible to mass rear and release the control agent to suppress the pest population. Under some conditions naturally occurring diseases may terminate what appeared to be an extensive insect outbreak. There is need for research to determine if such insect pathogens can be propagated in the laboratory and disseminated by man to control pests. The benefits of biological control of insect pests will be a savings from need to use other control measures and less use of possible pollutents.

OBJECTIVE: To determine the fauna and ecology of parasites, predators, and insect pathogens attacking pests of corn, sorghum and millet and to devise techniques for developing these agents for integrated control programs.

RESEARCH APPROACHES:

A. Search for parasites, predators, and pathogens of insects in their native home and when found evaluate, propagate, introduce and disseminate these agents in the area where the host insect occurs.

B. Determine the biology and evaluate the effectiveness of both native and introduced parasites, predators and diseases for the control of major insects attacking corn, sorghum and millet.

C. Evaluate the effect of insecticides and various cultural practices on the parasite and predator population.

D. Determine levels of naturally occurring and introduced biological agents needed to supplement other management methods.

E. Identify insecticide-resistant strains of parasites and predators for release.

F. Develop techniques for mass production and release of parasites, predators and insect pathogens, and evaluate various time and rate of release of these organisms for maximum effectiveness.

G. Combine the use of biological factors with various other techniques into integrated insect management systems suitable for use by corn, sorghum and millet producers.

H. Coordinate findings with RPA 209-D.

TITLE: Biology, taxonomy, physiology and nutrition. RPA 207-D

SMY:

	Number
Current	5.0
10% increase	5.0
Recommended	7.0

PRIORITY: 2

SITUATION EVALUATION: Various elements of the environment may unleash the tremendous reproductive potential of insects. Therefore, there is a need to know more about the interaction of the environment with insects so that more accurate predictions of outbreak potentials can be made to avert crop losses. Knowledge of insect classification, life cycle, rates of increase, migration, host range and other biological, ecological and physiological characteristics is essential to integrate chemical, cultural, biological and other methods of control. Only through a thorough knowledge of a pest's life cycle and population dynamics can one hope to aim control measures effectively at its most vulnerable stage. Accurate determination of insect species plays an important role in the foundation for basic and applied entomological research. The benefits from this research cannot be given in dollars, but it will facilitate and speed gains from integrated management systems.

OBJECTIVE: To determine the life history, distribution, abundance, nutritional requirements, and other biological, morphological, physiological and ecological characteristics of insects which may be of value in developing pest management systems.

RESEARCH APPROACHES:

A. Complete taxonomic studies on all developmental stages of insects attacking corn, sorghum, and millet as a foundation of valid identification procedures.

B. Determine mating, feeding, migration, alternate host plants and population dynamics including life tables of major corn, sorghum and millet insects and use this information to develop integrated control techniques.

C. Determine the physiological processes of insect development and interpret and evaluate such information as a possible means to develop integrated control measures.

D. Determine the variation in ecological, physiological and morphological characteristics of insect species from different geographical populations.

E. Determine the factors which influence insect population fluctuations.

F. Determine the genetic variability within the insect population.

G. Develop artificial rearing media for insects so that nutritional requirements can be refined.

H. Develop process equipment and environmental control for mass rearing, handling and distributing insects used in host plant resistance or biological control methods.

TITLE: Cultural practices. RPA 207-E

SMY:

	Number
Current	0.5
10% increase	0.5
Recommended	0.8

PRIORITY: 3

SITUATION EVALUATION: The practices involved in corn, sorghum and millet culture are presently in a highly dynamic state involving trends toward monoculture, higher plant population, increased commercial fertilizer application, narrow rows, use of herbicides and minimum tillage, irrigation, etc. representing an intensified agriculture. Frequently, a slight modification in the growing of a crop may influence insect damage. A thorough knowledge of the life history of a pest species is essential in developing cultural control methods. Crop rotation may be effective for insects with a restrictive food habit or those having limited power of migration. Fall plowing or crop refuse destruction may kill insects hibernating in or on soil or in crop refuse. When cultural control practices are also desirable agronomic practices, they are usually readily adopted. However, when they are poor agronomic practices, it is necessary to carefully weigh the advantages and disadvantages before these methods should be recommended. A change in cultural practices to control one insect may cause another insect which has not been important to become more prevalent. Changes in insect populations which accompany changes in management practices must be detected, and methods must be developed immediately to control these insects. Cultural practices alone may not give completely satisfactory insect control; nevertheless, they are often important in minimizing injury, and should be considered in any area-wide integrated control program. If entomological research on cultural control is to keep pace with agronomic production research, the entomologists must work cooperatively with all scientists who are concerned with corn, sorghum and millet production. Benefits would be to permit new management practices to be used without increasing insect damage.

OBJECTIVE: To determine the effect of crop management practices on insect population and to identify changes in insect incidence associated with new management practices.

RESEARCH APPROACHES:

A. Study the effect of various crop rotation, tillage and crop residue management practices on the insect population.

B. Evaluate the effect of time, rate and method of planting, seedbed preparation and fertilizer application, and irrigation practices on insect infestations.

C. Determine the effect of plant characteristics such as height, maturity, protein content, prolificacy and excessive tillering on insect population and damage.

D. Determine if new insect biotypes might develop due to a change in cultural practices.

E. Identify changes in insect incidence due to acceptance of new management practices.

F. Determine changes in ecology and micro-environment from changes in management practices and how these affect insects.

G. Coordinate findings with RPA 208-D, 209-A, 307-C, and 308-A.

TITLE: Non-Insecticidal manipulators (attractants etc.). RPA 207-F

SMY:

	Number
Current	2.0
10% increase	2.2
Recommended	4.2

PRIORITY: 2

SITUATION EVALUATION: Several new approaches to insect control offer good possibilities. The use of insects for their own destruction by employing the sterility principles has been demonstrated successfully for controlling the screwworm and certain tropical flies. It has been shown that when sterile insects are released and compete with the normal insects for reproduction, the biotic potential of the natural population can be greatly reduced. Insects are attracted to various stimuli, including specific substances in host plants, to natural products such as sex attractants produced by insects themselves, and to light, sound and other electromagnetic radiations.

The use of chemosterilants in conjunction with attractants that will lure insects in large numbers has good possibilities for controlling some insects. The use of natural or synthetic hormones as a possible means for development of methods to interfere with or interrupt insect growth and reproduction needs to be investigated. These various new approaches need to be considered in any integrated control program. Research conducted in RPA 207-G could result in more efficient and permanent insect control than chemical insecticides, alone.

OBJECTIVE: To investigate methods of sterilizing insects, isolate attractants, hormones, or other biologically active materials and use this information in developing management systems.

RESEARCH APPROACHES:

A. Determine the feasibility of applying the concept of area population suppression for the control of the major corn, sorghum and millet insects utilizing the principles developed in sterile male release technique, attractants, genetic lethals, etc.

B. Determine genetic systems in strains and races of insects that can be utilized to reduce viability or fecundity, and mass release these types.

C. Isolate attractants from plants or insect sex attractants and investigate the feasibility of using these in conjunction with other management practices.

D. Evaluate light, sound and other electromagnetic radiations as insect attractants.

E. Evaluate the effect of natural or synthetic hormones on the growth and reproduction of insects.

F. Combine the use of these new approaches with various other techniques into integrated insect control systems suitable for use by corn and grain sorghum producers.

TITLE: Insecticidal control. RPA 207-G

SMY:

	Number
Current	2.5
10% increase	2.5
Recommended	3.0

PRIORITY: 4

SITUATION EVALUATION: Discoveries of new synthetic insecticides and improved methods of applying them have made it practical to use insecticides to control many insects attacking corn, sorghum and millet. Private industry has assumed the major responsibility for developing new and more effective synthetic insecticides, but it remains the responsibility of the public agencies to determine their effectiveness for control of specific insects on specific crops. Several insecticides reduce the population of beneficial parasites and predators and may be toxic to wildlife.

Although tolerances have been set on several insecticides for use on corn, sorghum, and millet these tolerances may not be accepted in all foreign countries thus affecting the export market. Because of these factors, research is needed to find materials that possess maximum biological activity against man, animals and other useful organisms in the environment. Special emphasis should be devoted to a search for

insecticides which do not accumulate in plant and animal tissues. Since many residue problems arise from insecticide drift to nontarget areas, there is need for improved formulation and insecticide application equipment, to reduce drift and obtain greater precision in application. Research conducted herein will increase the use efficiency of chemicals in insect control.

OBJECTIVE: To develop integrable and economical chemical control methods that will minimize residues, reduction in beneficial insects and air, soil and water pollution, and be nonhazardous to higher animals.

RESEARCH APPROACHES:

A. Evaluate insecticides for control of corn, sorghum and pearl millet insects on growing plants and in grain in storage.

B. Test different insecticide formulations, rates and time of application.

C. Devise criteria to use in making decisions of the need for and time of application of insecticides for insect control.

D. Evaluate recommended insecticides against major corn, sorghum and millet insects from various locations to detect if the insects are becoming resistant to insecticides.

E. Determine the nature or cause of insect resistance to specific types of insecticides.

F. Develop integrated methods for insect management using combinations of an insecticide, insect attractants, plant attractants, feeding stimulants, host plant resistance and biological agents.

G. Evaluate the effect of insecticides on beneficial insects and wildlife.

H. Determine phytotoxicity and compatibility of pesticides.

I. Determine insecticide residues, and degradation in the plant and soil.

J. Develop design--performance criteria, and techniques for application of insecticides to improve insect control, reduce amount of chemicals required and reduce amount of drift.

K. Coordinate findings with RPA 208-A, 208-D, 209-C and 209-F.

RPA 208

CONTROL OF DISEASES AND NEMATODES

INTRODUCTION

Diseases annually reduce yields of corn, sorghum and millet. When local conditions are favorable, certain diseases develop in destructive proportions and cause grave losses. Production hazards due to diseases are expected to increase as cultural practices for these crops intensify. Continued effort in disease control at the present level is inadequate to prevent losses from becoming even greater. Greatly expanded research efforts are needed to substantially reduce current losses. The studies must be broadly based, comprehensive, and multi-disciplinary. Close cooperation with private industry must be maintained.

The research is detailed in the following 5 problem areas: (a) identification, etiology and development of diseases, (b) genetics of plant-pathogen interactions and control of disease through genetics and breeding, (c) nature and mechanisms of disease resistance, (d) control of disease through the use of pesticides and management practices, and (e) storage diseases and relationship of disease to quality.

TITLE: Identification, etiology and development of diseases. RPA 208-A

SMY:

	Number
Current	4.2
10% increase	5.0
Recommended	8.5

PRIORITY: 1

SITUATION EVALUATION: Numerous fungi, bacteria, viruses, nematodes, and parasitic seed plants are known to attack corn, sorghum, and millet and cause reductions in yield and quality. Other losses are caused by non-infectious agents. In recent years these crops have been severely damaged by viruses and related microorganisms. Several pathogens have the potential of causing complete distruction of the crop if not controlled.

Others are capable of causing yield losses from 10 to 75 percent. A few diseases have never developed in destructive proportions. In other crops, however, minor diseases of this type have become major diseases when crop varieties and cultural conditions have appreciably changed. Recently, root and stalk rots have increased in prevalence and severity. About 15 years ago a downy mildew previously found only in Africa was identified in Texas and has since been spreading in the U. S. Several other pathogens causing important diseases in other countries are not known to occur in the U. S. Examples are different species causing downy mildew in Asia, bacterial and fungal stalk rots in India and

Egypt, ergot and smut diseases in Africa, and virus diseases in Europe. The danger of introducing such new pathogens or new races of old pathogens is continually present. Thus, new disease problems arise while older ones are continually changing.

Information on the nature, cause, and epiphytology of disease is basic to intelligent development of proper control procedures. Therefore, the benefits from this activity are directly related to those obtained from disease control through breeding or use of pesticides and management practices. In addition, losses that might occur through unwise changes in cultural practices could be anticipated and avoided. The magnitude of potential benefits cannot be quantified specifically, but they would be included in those of 207-B and 207-D.

OBJECTIVE: To gain a more thorough understanding of the causes of corn, grain sorghum and millet diseases, the pathogens and agents of these crops, the factors influencing disease development and the effects of disease on the efficiency of the plant.

RESEARCH APPROACHES:

A. Identify the pathogens and noninfectious agents causing disease and determine life cycles, host ranges, methods of transmission, spread and infection by pathogens including viruses and nematodes.

B. Study development and survival of saprophytic stages of pathogens causing root rots, stalk rots and other diseases.

C. Determine the external factors (environmental) affecting disease development with particular emphasis on root and stalk rots.

D. Identify foreign diseases of potential importance and study the disease and its causal agent in areas where it is a problem.

E. Determine virus movement and increase within the vector(s), and the relationship of vector movement between and within fields on the spread and development of virus and bacterial diseases.

F. Determine crops and other plants that may serve as alternate hosts of viruses, nematodes and other pathogens and the significance they play in disease development.

G. Determine the effect of viruses, foliage pathogens, nematodes and insects on the development of other diseases with particular emphasis on root and stalk rots.

H. Conduct disease surveys and develop improved methods of calculating crop losses.

I. Use genetically similar resistant and susceptible host strains or chemical control to determine extent and type of plant injury caused by pathogens including viruses and nematodes.

J. Develop effective inoculation techniques for creating artificial epiphytotics to facilitate studies of injury and control.

TITLE: Genetics of plant-pathogen interactions and control of disease through genetics and breeding. RPA 208-B

SMY:

	Number
Current	5.0
10% increase	6.0
Recommended	8.0

PRIORITY: 1

SITUATION EVALUATION: Large reductions in yield, quality and efficiency of corn, grain sorghum and millet production are sustained each year as a consequence of disease attack. Fortunately, resistant hybrids now materially limit the potential destructive development of many diseases of these crops. A real danger exists, however, that present gains in genetic control may be lost if inadequately tested hybrids are put into production, if pathogens change in their virulence, if new pathogens or races are introduced, or if cultural conditions change to exceed stress levels of present hybrids. Resistance to root and stalk rots and to nematodes is presently inadequate. Inbred lines, varieties and hybrids differ in resistance to one or more diseases. Frequently, these stocks are resistant to only one or a few diseases and are susceptible to others. In many instances, lines used as sources of resistance are unsatisfactory in yield, adaptability and other agronomic characteristics.

Resistance to a given disease can take several forms. Some forms are effective against specific strains or races of a pathogen. To these forms of resistance, genetic changes can occur in pathogens enabling them to overcome the barriers imposed by the resistant plant. Other forms of resistance are less specific. The genetic nature of resistance to most diseases and nematodes is, for the most part, unknown. Numerous genes for resistance to the rust and leaf blight diseases in corn and to smut diseases in grain sorghum have been identified. The genetic nature of resistance to other diseases remains to be determined. Little work has been done on the inheritance of virulence and the genetic variability in the pathogens of these two crops.

Excellent programs on applied breeding for disease resistance in corn, grain sorghum and millet are underway. Commercial plant breeding firms are poorly staffed and equipped to do sophisticated research on disease resistance. Applied breeding efforts are presently largely empirical and often inefficient.

Production costs and hazards will be reduced, grain yields increased and quality improved. Reliability of crop production will be increased because of reduced genetic vulnerability. Potential losses from foreign diseases might be avoided or reduced because of the incorporation of

resistance. Furthermore, useful resistance genes may be conserved because of their subtle deployment. Increased levels of resistance to foliar and root and stalk rot diseases could result in savings of several millions of dollars annually.

OBJECTIVE: To identify and evaluate the relative effectiveness of various sources of resistance to disease, study the genetics of host-pathogen interactions, determine the most efficient breeding procedures, and transfer superior forms of disease resistance to plant types that can be used to produce productive well-adapted hybrids.

RESEARCH APPROACHES:

A. Observe available germplasm, including exotic varieties and wild relatives, for reaction to specific pathogens, viruses and nematodes with particular emphasis on those associated with the root and stalk rot diseases.

B. Develop disease resistant synthetics and other source populations from which superior inbred lines may be isolated, both for domestic and foreign diseases.

C. Determine the identity, number and action of genes conditioning each form of resistance.

D. Study the variability and genetics of the various pathogens, viruses and nematodes with particular emphasis on pathogenicity.

E. Develop appropriate genetic stocks for maintaining genes for resistance and for use in studies on the nature of disease resistance and genetic nature of host-pathogen interactions.

F. Determine the relative efficiency of various breeding procedures for (a) development of source populations, and (b) for transferring disease resistance to an established inbred line.

G. Coordinate with research in RPA 307-D.

TITLE: Nature and mechanism of disease resistance. 208-C

SMY:

	Number
Current	4.0
10% increase	4.2
Recommended	6.5

PRIORITY: 1

SITUATION EVALUATION: Host resistance and tolerance are among the more important means for controlling diseases of field crops such as corn, sorghum and millet. Recent research advances and theories account for only a portion of our understanding of the nature of resistance. Certain

mechanisms appear to be effective against a wide range of pathogens while others are effective against only a few races of specific pathogens. A more thorough understanding of these and other physiological resistance mechanisms will aid in the selection of improved techniques for incorporation of resistance into agronomically useful cultivars.

Other forms of host resistance to disease include morphological and functional characters. The use of these natural host barriers to pathogens may complement other resistance mechanisms and aid substantially in reducing losses and the rate of spread of the pathogen in a population of plants.

OBJECTIVES: To gain a more thorough understanding of disease resistance and to provide insight in utilization, incorporation, deployment and development of resistant cultivars.

RESEARCH APPROACHES:

A. Characterize the biochemical and biophysical basis for compatible (susceptible) and incompatible (resistant) host-parasite interactions.

B. Determine the extent of the effect of morphological plant characters on pathogen and disease development.

C. Define the interaction of selected and different resistance mechanisms on pathogen variation (gene stabilization) and development of epidemics.

D. Coordinate research with other RPA's 207-A and 307-D.

TITLE: Control of disease through the use of pesticides and management practices. RPA 208-D.

SMY:

	Number
Current	3.0
10% increase	4.0
Recommended	6.0

PRIORITY: 2

SITUATION EVALUATION: Corn, grain sorghum and millet varieties and hybrids resistant to all diseases are not available and are not likely to become available in the immediate future. Adequate resistance may not be possible for certain diseases. Therefore, investigations to develop alternative control measures are needed. Many seed and soil-borne diseases can be controlled through the use of fungicide and treatments. Chemicals should be tested and superior products identified.

Populations of insect vectors of viruses and other pathogens and populations of nematodes (both as primary pathogens and as vectors of other disease agents) can be reduced through the use of insecticides and nematocides.

Recent developments in the control of leaf diseases of cereal crops with low volume spraying of fungicides suggest that control of foliage diseases of corn and grain sorghum by this means may be feasible. New systemic fungicides are effective against smut diseases of wheat and barley and should be tested on corn and grain sorghum. Losses due to nematodes and root and stalk rots of these crops may be reduced through the application of suitable management practices. It may also be possible by this means to keep to a minimum the injurious effects of toxic residues in the soil. These residues are derived from impurities and break-down products of herbicides, commercial fertilizers and other chemicals.

Production hazards will be reduced, grain yields increased, and quality improved. Approximately four percent of the corn disease losses and three percent of the grain sorghum losses due to diseases are of the type that might be saved by the application of pesticides and development of proper management practices.

OBJECTIVE: To study and develop effective means for the control of corn, grain sorghum and millet diseases through the use of pesticides and management practices.

RESEARCH APPROACHES:

A. Study the effectiveness of various types and rates of chemical seed treatments for use in the control of seed- and soil-borne diseases, determine superior materials and methods of application.

B. Study the effectiveness of various insecticides and nematocides for use in the control of insect vectors and of nematodes, and determine superior materials and methods of usage.

C. Test chemical agents for systemic or localized control of foliage, root, and other diseases and develop techniques for the effective use of such agents.

D. Study hyperparasitism as a method for control of phytopathogenic fungi, bacteria and nematodes, with particular emphasis on those associated with the root and stalk rot diseases.

E. Develop effective management practices including fertilizer application, nutrient balance, irrigation, pesticide application and others that are compatible with sound crop production methods and also effective in reducing or preventing losses due to root rot, stalk rot, and other diseases.

F. Study the phytotoxicity, compatibility with other pesticides and residues of chemical seed treatments and vector control insecticides and nematocides.

G. Coordinate with research in RPA's 207-E, 207-F, 209-A and 308-A.

TITLE: Storage diseases and relationship of disease to quality. RPA 208-E

SMY:

	Number
Current	2.0
10% increase	3.0
Recommended	3.0

PRIORITY: 3

SITUATION EVALUATION: Corn and grain sorghum grain is frequently harvested and stored at moisture levels that permit molds, bacteria, and insects to flourish. Both grain sorghum and millet frequently undergo field deterioration caused by common fungi during wet harvest seasons. Improper storage of silage also favors spoilage. When stover and grain is left standing in the field and harvest delayed for winter feeding of livestock, the plant becomes covered with fungal growth. These microorganisms reduce feeding quality and frequently introduce toxic by-products harmful to man and livestock into the substrate. Corn infected by Gibberella spp. is particularly toxic to swine. Grain types with modified proteins high in lysine appear to be more susceptible to ear and kernel diseases. This could be of considerable importance in relation to world food needs. Of even greater importance is that toxins carcinogenic to man and animals are produced by species of Aspergillus, Penicillium, and other fungi growing on corn and sorghum grain.

Reduced loss of livestock production from consumption of low quality or toxic feed, prevention of injurious effects on man, and increased seed quality would occur. The magnitude of potential benefits is difficult to quantify because the value of human health cannot be expressed in monetary units. In terms of animal and crop production, however, benefits would involve millions of dollars annually.

OBJECTIVE: To study the effect of moisture content, storage conditions and grain endosperm types on storage and kernel-rot diseases, the effect of weather and other factors on spoilage of stover, grain and silage, the effects of these and other diseases on quality, and to develop means of preventing losses.

RESEARCH APPROACHES:

A. Identify the various molds and bacteria including identification of toxic products developing on grain, stover, and silage and determine their effects on feeding, processing and seed quality.

B. Determine the relationship of endosperm type to ear- and kernel-rot susceptibility.

C. Determine the conditions favorable for mold and bacterial growth, production of their toxic by-products, and develop means of preventing the growth of these organisms.

D. Coordinate with research in RPA's 207-G, 208-A, 308-B and 408-B.

RPA 209

CONTROL OF WEEDS AND OTHER HAZARDS

INTRODUCTION

Annual and perennial species of weed grasses, broadleaf plants, and sedges infest fields in which corn, grain sorghum and pearl millet are grown. Much of our cultural system of producing these commodities (seedbed preparation, row width, rotations, tillage practices, fertilization, etc.) has been greatly influenced and restricted by the necessity of providing for weed control. Weeds reduce yields and quality, increase the cost of production and harvesting, harbor insects, and are alternate hosts for diseases and nematodes.

Estimates from Losses in Agriculture indicate that weeds reduce yields of corn by 10 percent of the potential yield, and by 13 percent for grain sorghum. In many individual situations, yield losses in excess of 50 percent due to weeds are common. Other hazards such as birds, mammals (e.g., deer, rodents), and extreme climatic conditions (e.g., frost, hail, wind) cause additional losses. There is a primary need, however, to better define crop yield losses from weed, bird, and animal pests.

TITLE: Develop management systems involving combinations of weed control practices. RPA 209-A

SMY:

	Number
Current	1.3
10% increase	2.3
Recommended	3.0

PRIORITY: 1

SITUATION EVALUATION: Although effective control treatments have been developed for specific weeds in some areas, no one treatment will control all problem weeds in all crops or areas. Treatments highly effective in one area will fail completely in another having different cropping systems or climatic and soil characteristics. One of our best approaches to obtain effective, practical control of the weeds in crops is the development of combinations involving two or more components of existing technology such as cultural practices, biological control, crop rotations, and herbicides. Currently, our most effective combinations of treatments for control of weeds in corn or grain sorghum include components as follows: (1) good seedbed preparation and one or two postemergence cultivations; (2) a banded or broadcast application of a herbicide at planting; and, (3) one postemergence, broadcast application of a herbicide. Very few farmers use more than two of these components and only limited research is being conducted to improve the efficiency of treatments

within different combinations and to develop combinations that are better than the ones we now have. Success in this research will enhance our ability to combine different treatments into systems of weed control aimed at specific weed complexes growing under each of the different environmental conditions that are involved in producing these crops. Knowledge about combining different systems of weed control along with optimum amount of soil manipulation needed for maximum yield will give a realistic basis for developing practical systems of minimum tillage.

OBJECTIVE: To combine individual weed control procedures and other cultural practices into practical and economical systems of crop production and weed control.

RESEARCH APPROACHES:

A. Study different combinations of herbicidal and cultural treatments applied in corn, grain sorghum, pearl millet and rotation crops for efficacy against specific complexes of weeds common within each geographic area of the region; coordinate this approach in different geographic areas.

B. Investigate the ecological effects of different combinations of cropping sequences, varieties, herbicide rotations, cultural practices, and biological control on the natural weed infestations.

C. Determine economics of weed control systems in terms of threshold levels and cost/benefit ratios.

D. Determine levels of herbicide residues in soil following various weed control systems and determine fate of herbicide in successive crops.

E. Develop practical systems of minimum tillage that will decrease production costs and improve soil and water conservation by combining the best parts of all weed control systems.

TITLE: Improved equipment for herbicide applications and physical methods of weed control. RPA 209-B

SMY:

	Number
Current	0.3
10% increase	1.1
Recommended	1.5

PRIORITY: 1

SITUATION EVALUATION: Hydraulic sprayers and granular application equipment are used to apply most of the herbicides to control weeds in corn, grain sorghum and pearl millet. Inadequate weed control and excessive use of herbicides frequently result because of inaccuracies in the rate

of application, lack of precision in placement, and lack of uniformity in distribution on plants and soil. When aircraft are used to apply herbicides, it is difficult to control the rate of application, obtain precise placement and uniform coverage, and prevent drift. Maintaining constant field speed with herbicide application equipment (either ground or air) is mandatory if correct application rates are to be maintained. Available equipment does not have adequate control of ground speed or control of the discharge rate so that it is automatically varied with speed. The use of tools such as plows, harrows, planters, and cultivators aid in controlling weeds. These tools may do an adequate job provided they are properly adjusted and used at the right stage of weed growth when soil and climatic conditions are favorable; however, the energy requirements are frequently high. Equipment and techniques for incorporating and injecting herbicides into the soil have been developed and are moderately successful under some conditions; however, improvements are needed. Also, new approaches to weed control need to be developed. A major problem in the development of new and/or improved equipment and methods of weed control in corn and grain sorghum is the lack of specific information on needed operational requirements. Knowledge of the influence of soil, climatic, crop growth, and weed growth conditions on the performance of new weed control equipment and methods also is essential to the development of design and operational specifications for the equipment.

OBJECTIVE: To determine needed operational requirements and develop design criteria for improved equipment for applying herbicides and mechanical weed control systems.

RESEARCH APPROACHES:

A. Determine type of herbicide granule or spray distribution needed for optimum effectiveness of herbicides for preplant, preemergence, and postemergence weed control.

B. Develop precision equipment for selective application of herbicides, sensors in directing sprays or granules, and speed/discharge control devices.

C. Develop recirculating spray systems to maximize use of a given herbicide volume and to minimize placement on non-target surfaces.

D. Develop operational systems of using curtains of air, water, or gas to control placement of herbicides or flame on weeds in crops; study methods of applying herbicides as foam, gels, or particulates.

E. Study methods of controlling drop size and eliminating ultrasmall droplets from spray nozzle applications as a means of reducing drift from the target area.

F. Study the effects of electromagnetic radiation and high-frequency sound on weeds and crops at different stages during their development; exploit these factors for weed control.

G. Develop improved seedbed preparation, improved planters, and optimum planting patterns (plant densities and spacings) that allow more precise herbicide applications; develop tool bars for conservation tillage and improved planting patterns and row spacings.

H. Analyze and use data on movement of specific herbicides in soil, mode of phytotoxic action, and requirements of weeds and crops for nutrients, water, and aeration in the development of design criteria for herbicide application and tillage equipment.

TITLE: Improve the effectiveness and safety of current herbicides. RPA 209-C

SMY:

	Number
Current	0.3
10% increase	0.6
Recommended	1.0

PRIORITY: 1

SITUATION EVALUATION: Many herbicides used have serious limitations because of drift hazards to adjacent sensitive crops, phytotoxicity to corn or grain sorghum, and persistence in soil at levels toxic to succeeding crops. There is a need for additional information on how herbicides move from the point of application and on their optimum persistence in soil, water, and plants for most effective weed control and minimum adverse environmental effects. The best available herbicides are only marginally effective against a number of weeds; research is needed to develop improved methods and formulations of application to increase their effectiveness.

OBJECTIVE: To obtain information on how herbicides currently available or their chemical derivatives can be used in new formulations and mixtures to obtain better control of weeds and reduce problems and hazards now being encountered.

RESEARCH APPROACHES:

A. Characterize the persistence and movement of herbicides in soil, air, water and plants.

B. Develop methods of controlling the movement and persistence of herbicides in soil, and of controlling movement from the target area.

C. Determine minimal quantities of herbicides which may be applied without loss of effectiveness by using mixtures of herbicides, adjuvants, and new application techniques to reduce costs and soil persistence.

D. Develop new combinations and methods of applying herbicides for selective herbicidal action against major problem weeds.

E. Investigate those factors which influence penetration, absorption, and translocation of herbicides in plants to improve activity and selectivity.

F. Develop herbicide resistant crop varieties to increase selectivity of herbicides to problem weeds and to allow this optimum and safe usage for weed control.

TITLE: Control of weeds by biological means. RPA 209-D

SMY:

	Number
Current	0.0
10% increase	0.0
Recommended	1.0

PRIORITY: 2

SITUATION EVALUATION: Nonchemical weed control, through the use of biological control agents, such as diseases and insects, for control of weeds in corn, grain sorghum and pearl millet has been investigated only to a small extent. The lack of adequate herbicides selective for certain weeds in corn and grain sorghum and the need to minimize contamination of the environment by herbicides available emphasize the importance of developing biological methods.

OBJECTIVE: To identify biological control agents and determine the means of effectively using them for the control of specific weeds in corn, grain sorghum and pearl millet.

RESEARCH APPROACH:

A. Evaluate the use of domestic and foreign insects, plant disease organisms, poultry, and small and large animals for control of weeds that are resistant to current methods of control.

B. Evaluate the replacement of native ditchbank and fencerow problem weeds with less troublesome plants as a means of reducing weed populations in adjacent fields.

TITLE: Comparative biology, physiology, and ecology of specific weeds and crops. RPA 209-E

SMY:

	Number
Current	0.7
10% increase	0.7
Recommended	1.2

PRIORITY: 2

SITUATION EVALUATION: Many annual and perennial weeds in corn, grain sorghum and pearl millet cannot be adequately controlled by present herbicides. Generally, little is known about the biology, physiology, and ecology of these weeds. Improved knowledge in this area could provide a basis for exploiting inherent weaknesses by mechanical, chemical, or biological control procedures, including the use of superior characteristics of improved varieties of corn and grain sorghum. With fundamental knowledge on weed/crop competitive characteristics and weed requirements for germination, establishment, growth, and reproduction, considerable gains can be made toward better control procedures, and in reducing residual levels of infestation.

OBJECTIVE: To determine and exploit differences in the biology, physiology, and ecology of problem weeds in corn, grain sorghum and pearl millet as a means of improving current control procedures and reducing future infestations.

RESEARCH APPROACHES:

A. Determine which weeds compete most with the crop and identify the stages of crop growth at which competition from various weed densities is most harmful and at which control measures must be applied to prevent yield losses; define crop yield losses by weeds in conjunction with other pest losses.

B. Determine what can be done to increase the competitive ability of the crop plants through selection of varieties and improvement of cultural practices, including use of early season varieties and herbicide resistant varieties.

C. Identify weeds emerging as new problems as a result of selective weed control pressure against species formerly occupying the ecosystem. Intensify research on these new hard-to-kill weeds.

D. Determine the requirements for germination, growth, establishment, and reproduction of problem weeds and how these can be exploited to provide better methods of control.

E. Determine the physiological basis for superior growth of weeds or crops with respect to utilization of nutrients, water, light, and release of inhibitory substances by plants.

F. Study the morphological and anatomical characteristics of weed plants at various stages in their growth and identify characters vulnerable to weed control measures.

TITLE: Mechanism of herbicide action and physiological-environmental interactions of herbicide effects. RPA 209-F

SMY:

	Number
Current	0.4
10% increase	0.4
Recommended	0.8

PRIORITY: 2

SITUATION EVALUATION: The site of action and associated physiology of seven of the herbicides used in corn and grain sorghum are known in general principle. The basis for tolerance by the crops is known for four. Herbicides used for both corn and grain sorghum are detoxified in the two crops by totally different mechanisms. Extension of the established principles to include problem weeds (primary targets for research) has been conducted only to a limited extent. The mechanisms of lethal action and of selective toxicity of numerous other recommended herbicides remain to be established. Most herbicides occasionally damage crops or fail to produce desired weed control. Better understanding of the principles of herbicide action as altered by environment and physiology in the specific weeds should lead to improved practices, and should be useful in the search for better herbicides. The chemicals whose actions are now known act at biochemical sites associated with photosynthesis, which are common to plants but absent in animals. Some herbicides not now used extensively in corn or grain sorghum act through multiple inhibitions; when one mechanism fails to control weeds, the second mechanism can still kill the plant. Complete knowledge of mechanism of action would reveal potential health hazards if they exist. There is a need to determine biochemical effects of herbicides and their derivatives and residues on animal systems.

OBJECTIVE: To determine the mode of action and basis of selective toxicity of herbicides as related to the life history, biochemical processes, and responses to environment of the crops and specific weeds, and to relate this information to the efficacy of herbicide usage.

RESEARCH APPROACHES:

A. Determine the effects of herbicides on various metabolic systems in major weeds and crop plants.

B. Determine physiological and biochemical differences between weed and crop species as related to response to herbicides.

C. Study the influence of environmental factors on the response of major weeds and both crops to herbicides.

D. Develop and test theories based on results of A and C above to explain herbicide action and selectivity, unexpected crop damage, weed control failure, and timing of applications for greatest weed susceptibility.

TITLE: Evaluation of new herbicides. RPA 209-G

SMY:

	Number
Current	1.1
10% increase	1.0
Recommended	1.0

PRIORITY: 3

SITUATION EVALUATION: The use of herbicides is presently one of the principal approaches to weed control and new and better herbicides continue to be needed. However, a large portion of the total weed control research effort by public agencies in the past and at the present time is devoted to the evaluation of new herbicide candidates. Industry scientists who develop these candidate chemical materials are in better situations to conduct the evaluations, particularly in the "screening" and "primary evaluation" stages. The limited manpower and resources now available for public research dictate that some of the existing efforts in herbicide evaluation be reoriented to the more effective use of presently available herbicides and to non-chemical weed control measures and research. However, there remains a need for public researchers to conduct advanced evaluations of new herbicides generated by industry scientists. This is true for corn and grain sorghum because there is a lack of adequate herbicides selective for the control of the few hard-to-kill weeds in these crops. Only priority 3 is identified with this total effort to reflect the need for public agencies to reorient much of their existing resources away from screening and primary evaluations. However, this latter approach should be very high priority with industry.

OBJECTIVE: To evaluate new improved herbicides.

RESEARCH APPROACHES:

A. Reorient current effort to the advanced evaluations of new herbicides that are more selective, safer to use, and have optimum presistence in the environment, as compared with current materials.

B. Reevaluate previously available experimental herbicides with emphasis on control of specific weeds in a crop and weed management system, as opposed to the classical system of evaluation on a broad spectrum of weeds.

TITLE: Techniques for repelling and excluding bird and mammal pests.
RPA 209-H

SMY:

	Number
Current	0.0
10% increase	0.0
Recommended	0.5

PRIORITY: 3

SITUATION EVALUATION: Birds and small rodents often damage, and sometimes destroy, plantings of corn, grain sorghum and pearl millet by eating the seeds or young seedlings. Deer, raccoons, birds and other animals damage corn and grain sorghum at all stages of crop growth. Birds frequently cause extensive damage, in some locations, by eating and shattering seed of mature grain sorghum just before harvest. Ordinary fencing, electrical fencing, noise-making devices, scarecrows, recordings of bird distress calls, predator scents and other chemical repellants, trapping, dynamiting of roosts, poisoning, and shooting may be used to repel, exclude, or kill birds and other wildlife pests. Methods which destroy the offending wildlife are highly objectionable for obvious reasons; other methods are generally low in effectiveness, expensive, or poorly adapted for use in large fields. Although we know that birds and other wildlife cause significant losses in corn, grain sorghum and pearl millet, we are currently unable to quantify these losses. We also know that wildlife, particularly birds, are beneficial in some respects; for example, biological control of insects and weeds.

OBJECTIVE: To identify, characterize, and mitigate losses caused by birds and other wildlife without killing or injuring the offenders.

RESEARCH APPROACHES:

A. Identify the exact species of wildlife involved in specific situations, and measure the benefits and losses they cause in these situations.

B. Investigate different types of flashing lights, recorded sounds, moving mechanical men and predatory animals, and other non-chemical techniques as repellants.

C. Develop economical and environmentally acceptable repelling chemicals, including "chemical frightening agents" that repel unaffected birds through adverse behavioral actions of affected birds.

D. Investigate the potential of using controlled sterilization to reduce population of rampant species such as blackbirds.

E. Investigate the potentials of breeding corn, grain sorghum and pearl millet for resistance to damage from wildlife.

F. Study different designs of common and electrified fencing for improved efficiency in excluding specific species of wildlife.

G. Investigate the potential of planting alternate "free-lunch" crops for offending wildlife in areas adjacent to crops.

H. Characterize the economics of public reimbursement of individuals sustaining severe losses in locations adjoining wildlife refuges.

RPA 307

IMPROVEMENT OF BIOLOGICAL EFFICIENCY

INTRODUCTION

During the past quarter century, striking yield increases have been achieved in corn, sorghum and pearl millet. Progress attained to date has come about as a result of a combination of factors including the development and use of improved hybrid varieties, the adoption of improved cultural practices and the greatly increased use of essential plant nutrients, especially nitrogen.

Comparable progress in the future requires improvements or "breakthroughs" in basic knowledge of physiology or biochemistry upon which applied technology can be based. For example, current methods of plant breeding have changed little since the introduction of hybrid corn, and are based largely on exploitation of the hybrid vigor exhibited by first generation crosses. Yet the genetic basis for hybrid vigor and the physiological-biochemical processes associated with the heterotic response are largely unknown quantities. Further significant progress is dependent upon the development of more efficient breeding methods.

Although the total volume of mineral nutrients used on corn and sorghum acreage has multiplied many times since World War I, adequate knowledge of the mineral nutrient requirements of these crops, especially when grown at high levels of production, is still lacking. Moreover, we are only beginning to develop an understanding of the micro-element requirements of these species.

Corn, sorghum and pearl millet plant types are what they are today because of selection in specific directions, and not because they are necessarily the most efficient plant types available. Corn, sorghum and pearl millet encompass tremendous genetic variability and are highly plastic species. Attempts should be made to use this variability to develop varieties that are less vulnerable to hazards of production and that are more efficient in the use of growth factors such as light and water.

Research in the past has been punctuated in terms of compartmentalization both between and among the genetic and physiologic disciplines. Efficient future progress depends on the integration of research approaches in these areas. For example, little is accomplished by increasing photosynthetic efficiency or the efficiency of utilizing respiratory energy if differentiation processes do not permit adequate economic sink development to capitalize on increased metabolic efficiency.

TITLE: Application of physiological, molecular and quantitative genetic principles to breeding. RPA 307-A

SMY:

	Number
Current	13
10% increase	13
Recommended	17

PRIORITY: 1

SITUATION EVALUATION: The success of hybrid corn is frequently cited as the outstanding example of the application of genetic principles to plant improvement. Breeders have made remarkable progress in improving both corn, sorghum and pearl millet. Yet, the methods by which success has been achieved have been largely empirical. With the use of current methodology, breeders are finding it increasingly difficult to make further significant improvement in productivity. Few attempts have been made to apply recent findings in physiological, molecular and quantitative genetics to selection schemes designed to further improve these crops. There is good reason to believe that substantial gains can be achieved. Ultimate benefits should accrue in the form of improved genetic potential for yield, pest tolerance, nutritive value and utilization of nutrients, light and water.

OBJECTIVE: To develop and test methods for applying the principles of physiological, molecular and quantitative genetics to plant breeding.

RESEARCH APPROACHES:

A. Investigate the relation of physiological and biochemical processes involved in protein, oil, and starch synthesis with yield and other economic characters.

B. Investigate relative efficiencies of different breeding and selection systems with respect to yield and other agronomic traits.

C. Evaluate methods for applying quantitative genetic principles to the genetic improvement of these crops.

D. Coordinate with research in RPA's 207-A and 208-B.

TITLE: Reduce genetic vulnerability and facilitate genetic improvement by the collection, evaluation and maintenance of germplasm. RPA 307-B

SMY:

	Number
Current	5
10% increase	6
Recommended	9

PRIORITY: 1

SITUATION EVALUATION: Uniformity within a crop can make it vulnerable to biological and environmental hazards, but genetic diversity within a crop can help avert widespread losses from such hazards. Concentrated and continued effort has resulted in world collections of corn, sorghum and pearl millet from wide geographical areas. The collections of these crops need supplementing from areas which have not been adequately searched.

Important tasks today are to evaluate and maintain germplasm collections and to convert exotic types to adapted forms. These collections of germplasm represent thousands of years of evaluation under domestication, and they are rich natural resources. Repeatedly they provide sources of improvement for yield, disease and insect control and nutritive values.

OBJECTIVE: To broaden the genetic diversity of corn, sorghums and pearl millet to reduce the genetic vulnerability of these crops, and to maintain rapid distribution facilities.

RESEARCH APPROACHES:

A. Exploit new genetic and cytoplasmic systems to facilitate the production of F_1 hybrids with greater nuclear and cytoplasmic diversity.

B. Evaluate species substitution as a way of reducing genetic vulnerability.

C. Develop obligate apomictic lines.

D. Collect germplasm not now in world collections.

E. Systematically classify collections.

F. Convert exotic germplasms to useful forms.

G. Develop systems for the efficient evaluation of introductions.

H. Develop germplasm pools and mixtures.

I. Develop and maintain computerized systems for searching the germplasm in storage for a given need.

J. Investigate new methods of storage to maintain viability over long periods of time.

K. Develop an efficient system of distribution of germplasm to qualified breeders and researchers.

TITLE: Development of plant nutrient requirements and cultural practices so as to maximize production and minimize environmental pollution. RPA 307-C

SMY:

	Number
Current	5
10% increase	6
Recommended	8

PRIORITY: 1

SITUATION EVALUATION: Fertilizers, particularly nitrogen, have been applied in increasing amounts to insure that lack of fertility does not limit yields. This has resulted in overfertilization in some cases. Overfertilization occurs because it is not possible with present technology to accurately predict the amount of fertilizer required. However, the present limited supply and greatly increased cost of fertilizer, coupled with the hazard to the environment resulting from overfertilization, demand a more efficient use of fertilizer. Data concerning optimum amounts, time of application and the macro- and micro- element requirements for each species are needed. Additional data are also needed regarding choice of variety, plant population, irrigation, weed control, multiple cropping and crop rotation.

The interactions between fertilizer requirements and cultural practices is especially important for efficient production and the prevention of stream and groundwater pollution.

OBJECTIVE: To develop basic information concerning fertilizer requirements and usages in relation to current cultural practices, and to evaluate combinations of cultural practices that will maximize production, minimize environment pollution, and be most economical.

RESEARCH APPROACHES:

A. Determine nutrient requirements including micro-nutrients, as affected by various cultural practices, especially rate, time and placement of fertilizers.

B. Evaluate cultural methods and cropping practices to provide elements of information needed for systems analysis (RPA 309) to determine the most economical production practices.

C. Identify and propagate those varieties that are most efficient in absorption, transport and utilization of nutrients.

D. Investigate and determine what practices provide optimum production with minimum levels of fertilizers, and with minimum environmental pollution.

E. Investigate the "associative symbiosis" aspects of nitrogen fixation in both C_3 and C_4 grasses.

F. Coordinate research with RPA's 207-E, 208-D, 209-A and 308-A.

TITLE: Genetic and cytogenetic studies on control of biological processes. RPA 307-D

SMY:

	Number
Current	4
10% increase	4
Recommended	7

PRIORITY: 2

SITUATION EVALUATION: Despite a vast store of knowledge on the phenotypic expression of numerous genes of corn and sorghum, little is known of the precise mechanism of gene operation. Information on gene action at the biochemical and molecular levels has been derived largely from work with the lower organisms (bacteria, fungi, etc.). Similar studies with higher plants of economic importance are needed if we are to understand the mechanisms of gene operation controlling important economic traits. Also more information is needed about linkage relationships among loci and their locations on chromosomes. More efficient use of genetic information about traits of economic importance should accure with this better understanding.

OBJECTIVE: To develop through genetic and cytogenetic studies a better understanding of inheritance of characters and of gene function.

RESEARCH APPROACHES:

A. Determine the inheritance of characters.

B. Investigate mode of gene action with special emphasis on economic characters such as new genetic-cytoplasmic male-sterile systems for producing hybrids, self-incompatibility and apomixis.

C. Determine the linkages and locations of loci that control traits of economic importance.

D. Determine the effect of gene location and chromosome structure on inheritance and breeding behavior.

E. Coordinate with research in RPA's 207-A and 208-B.

TITLE: Efficiency of solar energy conversion to grain and forage.
RPA 307-E

SMY:

	Number
Current	3
10% increase	3
Recommended	6

PRIORITY: 2

SITUATION EVALUATION: Light is the energy source for all growth and development processes of the plant. Therefore, it would seem that maximum yields would be obtained through management that would optimize total leaf surface per acre over the greatest number of days of the growing season thus permitting the capture of the highest amount of radiant energy consistent with soil water availability. Also, internal leaf characteristics and processes may vary among cultivars with respect to capture of solar energy.

The problem is complicated by the interaction of: (a) leaf width; (b) leaf angle; (c) plant population; (d) growth rates during different stages of plant development and maturation; (e) the physiological efficiency of light-driven photosynthetic reactions as affected by leaf position (number) at various stages of plant development and number and location of ears or heads (sumps); (f) the capability of the various leaves and their vascular systems to transport the products synthesized to the proper organ at the right time; (g) day length and growing season; and (h) changes in photosynthetically active radiation during cloudy weather. The problem resides in the fact that not enough basic information is available on the individual factors to permit an overall assessment and solution. Further, efficiency in solar energy conversion needs to be related to deficits of plant water and mineral nutrition.

Identification of the factors related to more efficient conversion of light energy to chemical energy by crop plants could permit the development of superior varieties and reduce the required amounts of energy applied through fertilizers and water.

OBJECTIVE: To evaluate individually and integrate the factors listed above so that the crop utilizes sunlight at maximum efficiency, permitting maximum grain and/or forage production.

RESEARCH APPROACHES:

A. Survey and/or utilize the existing germplasm for studies on leaf anatomy and morphology and their interaction with plant population.

B. Evaluate the physiological efficiency of various genotypes with respect to differences in internal leaf structure and/or characteristics that might affect capture of solar energy, and with respect to the ability of the leaves at various positions and

stages of development and various levels of solar radiation to (a) fix CO_2 (b) reduce nitrate (c) synthesize protein (d) convert light energy to chemical energy and (e) the efficiency of transport from these leaves to other parts of the plant.

C. Investigate the existing single gene mutants that modify plant geometry so that leaf canopy, leaf width, leaf angle, plant height and seed bearing structures can be evaluated both individually and in combinations in certain ecosystems. Needed information on the measurements of the effects of these genetic factors on variables of the ecosystem and their interactions should point the way to the plant geometry necessary to maximize grain and forage yields.

D. Determine optimum maturity and planting date so that grain filling occurs during a period of favorable radiant energy.

E. Evaluate the effects of deficits in plant water and mineral nutrition on efficiency of solar energy conversion.

F. Use computer simulation (modeling) to make preliminary evaluation of different leaf angles and plant population combinations.

G. Correlate with RPA 307-F.

TITLE: Fundamental studies of physiological and metabolical plant processes. RPA 307-F

SMY:

	Number
Current	4
10% increase	4
Recommended	6

PRIORITY: 3

SITUATION EVALUATION: Although genes specify the kind and amount of enzymes that function in the overall metabolism of a plant, they are not the only underlying basis for physiological advantages of specific genotypes. The whole of metabolism is a complex problem of the interrelationships of genes (and their associated products) and environments (both micro and macro). Research has barely begun on the various biochemical and metabolic pathways involved in growth and development of higher plants. Plant morphology, phenology and ontogeny, as affected by ever changing field conditions, influences final plant yield, and yet almost no research has been conducted to determine the interrelationship between the field microenvironment and these plant development disciplines. Research of this type should be conducted with crop plants that provide the world's food supply rather than obscure plant species.

Studies of physiology (biochemistry and metabolism) provide basic information needed for improvement in breeding, use of fertilizers, resistance to disease and insects and tolerance to environmental stress. Benefits will be derived in development of varieties with greater yield potential, savings in time required to develop such varieties, and more efficient use of fertilizers and herbicides.

OBJECTIVE: To develop a clearer understanding of the basic biosynthetic pathways in plant growth and development and to provide biochemical criteria useful to plant breeders in the development of superior crop varieties.

RESEARCH APPROACHES:

A. Determine the basic biochemical and physiological processes in-involved in starch, oil and protein synthesis and subsequent deposition in grain and forages.

B. Determine the efficiencies of the basic processes and the lengths of time the processes are permitted to function in terms of total production per unit of land area.

C. Investigate gene action sequence involved in carbohydrate, oil and protein biosynthesis.

D. Determine if enzyme systems can be used as a basis for selection of superior varieties.

E. Investigate and develop knowledge concerning the natural hormones with special emphasis on level and interaction of these hormones with external factors on metabolism and differentiation throughout the life of the plant, especially as they influence maturity, height and yield (size of floral parts).

F. Screen various chemicals in an attempt to find growth regulators and sterilants useful in production.

G. Investigate physiological plant responses to the dynamic microenvironment experienced by field grown plants.

H. Investigate new nuclear-cytoplasmic interactions and relate to male sterility systems for producing hybrids.

I. Investigate tissue culture relating to the fusion of haploid cells.

J. Coordinate with research in RPA 307-A, 307-B and 307-D.

TITLE: Improvements in efficiency of plant water utilization. RPA 307-G

SMY:

	Number
Current	4
10% increase	4
Recommended	7

PRIORITY: 3

SITUATION EVALUATION: Water is considered to be a major, if not the first limiting factor in corn, grain sorghum and millet production. Although irrigation reduces this problem, less than 10 percent of corn and 30 percent of grain sorghum acreage is irrigated in the Southern Region. Limited availability of irrigation water and the limited and varied amount of precipitation during the growing season necessitates improvements on the efficiency of water use. It seems most unfortunate that less than 1 percent of the water absorbed by plant roots is utilized directly in plant growth. However, the movement of water into and through the plant aids such functions as movement of solutes into and within the plant, and plant temperature regulation via evaporation (transpiration).

Since water is lost from the plant (transpiration) in the gaseous (vapor) form, attempts to reduce this loss by chemicals or films also tends to interfere with plant metabolism or reduce uptake of gaseous CO_2, as well as interfere with temperature regulation by the plant. Thus the system involved in efficient water use is complicated and encompasses such additional factors as (a) availability of soil water, (b) root type and distribution, (c) plant and leaf anatomy and canopy and (d) environmental factors of light, temperature, relative humidity, and wind movement. Only recently has the complexity of this problem been fully realized and the system soil-plant-atmosphere continuum (SPAC) been defined and studied as a whole. Because of the complexity of this system, team research constitutes one of the major, but not exclusive approaches. Practices or varieties that permit more efficient use of water would increase productivity and efficiency of land use.

OBJECTIVE: To extend the basic knowledge of the individual factors involved in water absorption, transport and evaporation from plants and integrate this information into a workable system that will lead to more efficient water use by crop plants.

RESEARCH APPROACHES:

A. Evaluate relationships of plant water deficits during the several stages of growth to plant development, yield, evapotranspiration and to plant water use efficiency.

B. Find chemicals or films that will reduce the evaporational loss of water from the plant but not reduce uptake of CO_2 into the leaf; evaluate the possibility of supplying carbon to the plant in some form other than carbon dioxide (e.g. carbonates).

C. Survey and select varieties and hybrids that exhibit efficient water use characteristics such as efficient root systems, low transpiration rates, metabolism that is resistant to environmental stress, and a final criterion of maximum grain production per unit of water used.

D. Extend the knowledge of plant temperatures and their measurements so that effect of temperature on water loss and plant development as mediated by metabolism can be effectively gauged. The influence of temperature on metabolic efficiency (and differentiation of yield components) is fully as important as the influence on water loss.

E. Investigate management practices such as narrower row spacing, limited or no-tillage, surface mulches of crop residues and alternate cropping systems to increase water infiltration and reduce soil-water evaporation, thus conserving water for use by plants.

F. Approach the problem as a whole (soil-plant-atmosphere continuum) which envisages cooperation with RPA's 207-E, 208-D, 209-A and 309.

RPA 308

MECHANIZATION OF PRODUCTION

INTRODUCTION

Advancing technology in all phases of corn, grain sorghum and millet production, particularly in mechanization, has made it possible to reduce the labor input from 46 hours per acre in 1880 to 2 hours per acre for today's better farmers. The successful substitution of mechanization for labor was made possible by substantial increases in the farmers' investment in mechanization. If the efficiency of corn and grain sorghum production is to be further increased, an expanded research program on the development of more efficient methods, techniques, equipment and structures will have to be undertaken.

Research on mechanization of production is concerned with the men, machines and materials used in the annual production of approximately one billion bushels of corn and grain sorghum on 16 million acres of land in the Southern Region. The potential for fruitful research is indicated by the sizable input of labor and equipment and the need for reducing costs, preserving quality and avoiding losses. For farmers to receive the greatest benefit, new developments in mechanization need to be evaluated in relation to other technological changes and to their combined effect on the total farm enterprise.

TITLE: Mechanization of production. RPA 308-A

SMY:

	Number
Current	1
10% increase	1
Recommended	2.5

PRIORITY: 1

SITUATION EVALUATION: Equipment and labor comprise a large portion of the inputs for corn, sorghum and pearl millet production. Most equipment was developed as individual units without regard to the total operational requirement. In many instances there is a lack of compatibility among power units, machine capacities, and operational requirements that is costly to the farmer. Labor inputs in corn and sorghum production have been reduced from 46 hr/A in 1880 to 2 hr/A or less in 1974. It has been estimated that by 1980, 1.0 to 1.3 hr/A will be common.

To obtain this high degree of mechanization, it has been necessary to make sizable increases in machinery investment. Using 1910 figures as a base of 100, the machinery investment by farmers increased 450 percent by 1967. Obtaining further substantial reductions in input cost

by substituting machines for labor does not appear promising. Reducing machinery inputs both in terms of machinery costs and machine operations offers promise. At the present time, the production systems and the equipment used in these systems must provide for seedbed preparation, fertilizer application, planting, weed control, insect control, disease control, irrigation, drainage, erosion control, harvesting and storage. An example of the types of cost reductions that have potential can be found in the recent work on tillage for corn production. Seedbed preparation uses more than one-half the total horsepower hours required to grow corn. It takes 36 to 40 percent of that total power to plow. Research has shown that it is possible to eliminate plowing in corn and sorghum production systems without reducing yields.

It should be possible to further reduce tillage operations or develop equipment to perform the necessary tillage with less power (minimum or no tillage systems). Before this can be done, the soil environment needed for seedling emergence and plant growth must be specifically described so that machines can be designed that will create that environment.

Fixed traffic pattern farm operations have been demonstrated to reduce soil compaction and improve soil water infiltration and improve root growth. This practice can reduce power and machinery requirements necessary for land preparations. Fixed traffic pattern schemes have had narrower row planting and wide bed systems imposed on it. Adaptation of these practices needs to be preceded by research into the effects on runoff and erosion and suitability with different soil types and integration with present farm management practices.

With the shortages in availability of agricultural fuels, increased efficiency in operations and reduced power requirements, however achieved, become necessary goals of research.

The results of this research should improve equipment and equipment selection, and should reduce the cost of production of corn, sorghum and pearl millet by 25 to 30 percent, a sizable portion of which should be a saving of energy.

OBJECTIVES:

(1) Develop design and operational specifications for equipment for tillage, seedbed preparation, fertilizer application, planting and controlling weeds, insects and diseases.

(2) Develop methods of system analysis and collect input data so that machines, machine operations and energy use efficiency can be evaluated as part of the total corn and sorghum production system.

RESEARCH APPROACHES:

A. Determine specific requirements for tillage and seedbed preparation so that machine design specifications and machines can be developed.

B. Determine specific requirements for planting and fertilizing so that machine design specifications and machines can be developed.

C. Utilize findings from RPA 207, 208, 209 and 308-B to develop machine design specifications.

D. Gather input data (time, fuel use, labor, etc.) for various field operations along with weather data so that job completion probabilities can be accurately determined.

E. Develop methods of analysis to evaluate experimental and presently available machines and machine operations which will maximize energy use efficiency.

F. Study the relationships of erosion control, irrigation and drainage on machinery operations associated with production.

G. Investigate the potential for wide bed, narrow row, fixed traffic pattern farming schemes.

H. Coordinate research with the following: 207-E, 208-D, 209-A, 209-B, 307-C, 307-G, 308-A and 309-A.

TITLE: Equipment and methods for harvesting, drying and storage. RPA 308-B

SMY:

	Number
Current	1.4
10% increase	1.4
Recommended	1.5

PRIORITY: 2

SITUATION EVALUATION: Harvest operations result in field losses of from 10 percent to as high as 30 percent of grain produced in the field. The combine is used to harvest grain sorghum and nearly one-half the corn crop is now harvested directly in the shelled form. However, mechanical damage to as much as 30 percent of the corn kernels has been observed. Rapid harvest requires mechanical drying for large volumes of high moisture corn and grain sorghum. During storage, losses occur due to molds, mycotoxins, bacteria and insects. The effect of all operations on grain quality is of increasing importance.

Results of this research should (1) reduce costs and preserve quality and quantity of grain, (2) reduce harvest losses by 3 percent, and (3) reduce drying and storage costs and losses by 2 percent.

OBJECTIVE: Develop new and/or improved methods and equipment for harvesting, drying and storing corn and grain sorghum for maintenance of quality with minimum labor, equipment and energy requirements.

RESEARCH APPROACHES:

A. Improve components of harvesting mechanisms to reduce field losses and mechanical damage, including investigation of squeeze shelling principle for corn.

B. Investigate new methods and equipment for harvesting for specific end uses, including new concepts for harvesting the total plant.

C. Improve equipment and methods for drying large volumes of shelled grain and determine effects on feed value and mechanical damage.

D. Investigate new techniques for drying grain such as microwave and infrared heating, vacuum drying, alternate heating and cooling, and multiple-stage drying.

E. Develop new and/or improved drying, storing and handling systems, and determine the effects of the different procedures on the physical and chemical properties of the grain.

F. Determine the deterioration rate of high moisture grain at various temperatures and the relation to mold and mycotoxin development.

G. Explore new techniques for grain storage including hermetic, insulated and refrigerated storage; controlled environment; and chemicals and inert gases to prevent mold development, chemical breakdown, loss in germination and insect problems.

H. Conduct studies on fumigants, protectants, environmental control and other methods of inhibiting the spread of stored-grain insects, with emphasis on nonchemical control methods.

I. Determine the maximum moisture content for safe storage of chemically-treated grain and the effects of various chemicals on nutrient and dry matter losses.

J. Determine physical properties of grain related to equipment and procedures for harvesting, drying and handling.

K. Develop methods, procedures and equipment for reducing air and noise pollution at grain drying installations.

L. Determine equipment and procedures for drying grain with minimum input of fossil fuels.

M. Coordinate the research in RPA 207-G and 208-E.

RPA-309

SYSTEMS ANALYSIS IN PRODUCTION
(Production Management Systems)

INTRODUCTION

The benefits of increased production efficiency, that is, lower production costs, are abundantly evident in our society. In continuing efforts to lower production costs farmers and researchers ask and require answers to many questions: What would costs be if the best method were used for each production job? Are these best methods mutually compatible? What production jobs offer the greatest potential for research aimed at cost reduction? What new techniques are needed to achieve significantly lowered costs for each job? Are there adjustments in enterprise combinations on farms which would contribute significantly to cost reductions? Would costs be lowered by certain interregional production adjustments?

Because of the wide scope of inquiry, research is necessarily conducted and reported by specialists within each of the several subject fields. Consequently, new techniques developed by research are seldom appraised rigorously in terms of their relationships with other practices in the production system. Choice of variety, method of tillage, time of planting, plant population, row spacing, type of equipment, timing, placement and amount of fertilizer, pest control practices and end-product use are mutually dependent characteristics of the corn and grain sorghum production system. Systems analysis requires a lucid specification of a system's components and facilitates rational, well-informed evaluation of choices for the several components.

There are a number of approaches to systems analysis in corn, grain sorghum and millet production. In general, a specific approach will entail (1) construction of a model or models to simulate grain production systems, (2) using the production system model(s) to evaluate extent, emerging, and hypothetical production systems and components under condition assumptions controlled by the investigator, and (3) field testing production systems and components selected by model analysis for validity under actual conditions.

TITLE: Optimizing production systems. RPA 309-A

SMY:

	Number
Current	1.7
10% increase	2.0
Recommended	4.0

PRIORITY: 1

SITUATION EVALUATION: Farmers must select from a number of possibilities the crop variety, production practices, materials and tools, and the operational sequence of their application which contribute optimally to attainment of their objectives. These selections must be mutually

compatible and flexible enough to allow for contingencies of weather, insects, disease and other hazards.

A realistic growth and production simulation model in which plants are responsive to the field environment can help in decision making. A growth simulation model can help advance knowledge faster and cheaper than extensive field and growth chamber studies. The model may ultimately be used to optimize farm management practices, predict yields, and indicate when crops will come to market. The model will be developed with presently available information but will require additional research for inputs into the model and to test the model once it has been developed.

More and better data are needed so that the effects of alternate methods of production, farm organizations and location of production can be determined. As the size of the farming units increases such information becomes even more important. An integrated modeling research program will produce the information necessary for optimizing production systems.

The research outlined herein will aid in the mutually compatible production operations that will optimize yield.

OBJECTIVE: Develop costs and returns data on production system components using computer simulation growth and management models which will enable farmers to put together optimal production systems.

RESEARCH APPROACHES:

A. Develop a realistic plant growth and yield simulation model in cooperation with work of physiology of RPA 307.

B. Use the plant growth model for optimizing management practices such as irrigation scheduling, timeliness of insecticide application, tillage controlled traffic patterns, planting date, row spacing, stand establishment, plant density, genetic height materials and soil moisture management.

C. Use the simulation growth model as a research tool to point out weaknesses in our understanding of plant production.

D. Identify production jobs with greater potential for cost reduction.

E. Identify and analyze alternative ways of doing these jobs.

F. Coordinate with work on RPA #'s which deal with plant growth and management practices.

TITLE: Evaluation of emerging technology. RPA 309-B

SMY:

	Number
Current	0.5
10% increase	1.0
Recommended	2.0

PRIORITY: 2

SITUATION EVALUATION: Continuing research develops new production techniques for consideration as a part of production systems. The number of these innovations and in many cases the sizable investment association with them, call for early evaluation in terms of their economic feasibility. Such evaluation would reduce the need for costly trial-and-error appraisal by farmers. This research will result in the reduction of production costs and minimize risks.

OBJECTIVES: Develop data on physical inputs and outputs and on costs and returns associated with important new technological developments when they first appear. Appraise the effect of selected new techniques on production costs and economic efficiency. Determine the effects of new techniques on the organization and income of farms of different types and sizes.

RESEARCH APPROACHES:

A. Investigate the resource requirements, costs and yields associated with various production practices such as variety selection, tillage, pest control, fertilization, plant and row spacing, and harvesting.

B. Evaluate these practices on representative farms to determine the probable impact of their use on the organization, operation and income of farms.

TITLE: Farm and regional equilibria. RPA 309-C

SMY:

	Number
Current	0
10% increase	.02
Recommended	2.0

PRIORITY: 3

SITUATION EVALUATION: Proper evaluation of economic potential of a farm enterprise requires its consideration as a part of the total farm organization. Enterprise evaluations *per se* are useful for certain purposes, but an enterprise cannot be completely evaluated until it is fitted into

a production organization. Certain complementary and supplementary relationships exist between enterprises which have a decided influence on the efficiency with which labor, machinery, capital, and other production resources can be used. Certain enterprise combinations may lead to more efficient use of production resources, and insofar as they do, they lead to hidden economies in the production of specific crops.

In addition, increased efficiency may be attained by effecting adjustments among farms and among regions. In one instance, systems analytic research indicated that the sale and transfer of cotton allotments from less efficient to more efficient farms can result in lower production costs and economic advantage for both seller and buyer. Similar increases in efficiency may be attained by shifting production from one region to another. Such situations, in which everyone benefits by transfer of production from farm to farm or from region to region, may exist for corn, grain sorghum and millet producers. Systems analytic research could discover these situations, reduce production costs, and improve net farm incomes. However, the dangers inherent in mono-culture should not be ignored.

OBJECTIVE: Determine the most efficient combinations of enterprises on farms producing feed grains, especially as they are affected by size of operation and level of technology. Indicate how increased efficiency may be attained by adjustments among farms. Determine potential increases in efficiency by adjustments among areas of production.

RESEARCH APPROACHES:

A. Production coefficients would be derived by production regions for farms of different sizes and with different soil sources, water, climates and using different levels of technology.

B. Using the above coefficients, systems analytic techniques would be used to determine optimum organizations for maximum profit for individual farm and least cost for regions.

C. Based on the above outputs, opportunities for adjustments among farms and among regions would be analyzed.

RPA-405

PRODUCTION OF CROPS WITH IMPROVED ACCEPTABILITY

INTRODUCTION

Corn and grain sorghum are our most important feed concentrates, and large quantites of both are also used by industrial processors. Pearl millet, an important grain crop in India and Africa, has potential as a source of quality protein, starch and oil. The composition and total amount of protein, carbohydrate and oil in the grain is under genetic control. Differences in digestability of sorghum grains have been established. Each of these sources of variability is of potential benefit as feed for livestock and food for man. Waxy corn and sorghum and high amylose corn are currently being used by the industrial processors. Sources of high lysine corn and sorghum have been found, and high lysine corn is in commercial use. Other genetic types affecting the characteristics of the stored proteins, carbohydrates and oil are known but their industrial potential has not been fully explored.

SMY:

	Number
Current	2.5
10% increase	2.5
Recommended	5.0

PRIORITY: 1

SITUATION EVALUATION:

A few percentage points of increase in digestibility of the grain (particularly sorghum) would result in increased feed efficiency, more rapid gains for livestock on feed and tremendous savings in grain. High lysine grains would result in greatly increased feed efficiency and savings of grain particularly when fed to swine and poultry. Since corn, sorghum and pearl millet are staples in the diet of many people in the world, grain with improved digestibility and nutritional qualities would result in savings of grain and more healthy people.

OBJECTIVE: To develop varieties of corn, grain sorghum and pearl millet having improved nutritional value and industrial processing characteristics and to establish the extent of genetic control for variation in amount and quality of the seed protein, carbohydrate and oils.

RESEARCH APPROACHES:

A. Develop agronomically acceptable types having improved protein quality.

B. Develop agronomically acceptable types with increased oil percentage which vary in degree of saturation of the component fatty acids.

C. Establish the basis for variation in digestability and incorporate the desirable characteristics into agronomically acceptable types. (Studies should include soft endosperm and brown seed-coat sorghums.)

D. Establish the inheritance of characteristics affecting grain and forage digestability and develop breeding methods for their improvement.

E. Search for other genetic systems which may have potential for increasing the nutritional or industrial value of these two crops.

F. Coordinate with research in RPA's 207-A, 307-F, 406 and 407.

RPA 406

NEW AND IMPROVED FOOD PRODUCTS

INTRODUCTION

Recent national harvests have been more than 5 billion bushels of corn and 900 million bushels of sorghum. Out of this huge total over a third of a billion bushels was converted into food and industrial products. The ratio of foods to industrial products was roughly 2 to 1. The corn wet-milling and dry-milling industries constitute the largest consumers of these grains after livestock feeding.

SMY:

	Number
Current	1.7
10% increase	1.7
Recommended	3.0

PRIORITY: 2

SITUATION EVALUATION: Changes in food technology that affect the use of cereal grains are occurring at an increasing rate. Increased research efforts are necessary to provide adequate data on the composition and properties of the grain and its constituents to permit conversion of grain into desired milled fractions for improved food products. Scientific and technological studies are required to develop new foods meeting tomorrow's standards of acceptability, nutrition and convenience.

Not only milled fractions, but also refined starches, sirups and sugars will find increased use in food products. New hybrids having higher contents of essential amino acids are being developed which are expected to increase the nutritive quality of corn food products and increase the demand for both domestic use and export. Enzymatic conversion of cereal starches to sirups and sugars of diverse carbohydrate composition is expected to make corn and sorghum more important sources of high energy foods. To realize the full potential of new outlets an expanded research effort will be required to develop more basic data on the physical and chemical properties of starch and protein.

Research in the area of the development of new and improved food products would increase the demand for corn and sorghum as raw materials for the dry milling and starch refining industries by: (1) improving processing efficiency, (2) developing improved milling technology, (3) lowering the cost of converting starch into sirups and sugars, and (4) developing new low-cost food products meeting the need of large markets. New grain fractions, starch-derived sirups and sugars of higher sweetening power, and new economical and nutritious food products could require an additional 100-million bushels of grain.

OBJECTIVE: To increase food uses of corn and sorghum by providing chemical, physical, and biochemical properties of grain, grain components and their derivatives, developing new process technology, and developing new food products.

RESEARCH APPROACHES:

A. Determine identity, amount, chemical structure and properties of constituents of standard and experimental varieties and hybrids of corn, sorghum and pearl millet.

B. Develop new and improved milling processes for corn and sorghum grain to obtain better yields and purity of fractions and constituents required for a wide variety of food products.

C. Develop new and improved enzymatic processes for converting starch into sweetening agents such as sirups, dextrose, fructose and higher saccharides.

D. Develop highly nutritious, readily digestible convenient and economical foods suitable for infants and the elderly.

E. Coordinate with research in RPA 405 and 407.

RPA 407

NEW AND IMPROVED FEED AND INDUSTRIAL PRODUCTS

INTRODUCTION

Large quantities of corn and sorghum are available annually. Consumption by the mixed feed, dry-milling and wet-milling industries is large and expanding. Experimental varieties are being rapidly developed, particularly of corn, which include types with higher quality protein, chemically different types of starch and types with higher content of oil or protein. Realization of current prospects will offer opportunities for increased uses in feeds and industrial products. Nationally, over 300 million bushels of these grains are dry or wet milled into flours, meals, feeds, starches and starch products, sugars and sirups. Somewhat over a third of these products are used for feeds and industrial products.

Research to improve the performance of starches, flours and their derived products will be necessary to meet specific industrial requirements. Research to provide essential information on composition and properties of milled fractions and refined products will form the basis of new processing technology and the development of new end products. Applied and development research is required to modify these grain products to better serve present applications and to discover new products and new applications.

TITLE: Development of feed products having increased palatability and nutritive quality for livestock. RPA 407-A

SMY:

	Number
Current	0.5
10% increase	0.5
Recommended	1.0

PRIORITY: 1

SITUATION EVALUATION: Formulation of feeds has become an extremely complex operation as better information regarding animal nutritive requirements has been developed. A limiting factor is the lack of reliable analysis of ingredients. Processing of feeds to improve feed efficiency may occasionally lead to detrimental effects. Very fine grinding and pelleting under some conditions are suspect in the occurrence of gastric ulcers in swine.

Inefficiency of cereal-based feeds in non-ruminant stock is due to low biological availability, particularly during early growth stages. Removal of cause of ulcers, in swine feeding and improved efficiency in use of cereals for poultry and swine would reduce cost of production. A decrease in feed costs of one percent would mean a saving of around

40 million dollars a year. The elimination of swine losses from ulcers is difficult to evaluate, but reduction of only a portion of the losses now occurring would make savings of millions of dollars.

OBJECTIVE: To increase the efficiency of use of corn and sorghum and perhaps pearl millet as feeds by providing more accurate and rapid methods of analysis for grain constituents, improving processing technology, and discovering processes for making cereal products more digestible.

RESEARCH APPROACHES:

A. Determine more accurate, more rapid and more economical analytical methods for important constituents in cereal grains. Develop improved methods for assay of standard and new varieties of grain.

B. Study the effect of grain processing procedures on biologically important constituents in grain as means of correlating processing with adverse effects in animal. Develop economical processing methods that are suitable.

C. Study the effect of enzyme treatments of cereal grain feed products on availability of protein, fat and carbohydrate content. Develop processes for the practical modification by enzymatic treatment.

TITLE: Discovery and development of new chemical products from corn, sorghum and perhaps pearl millet starches and flours for use in large-volume industrial applications. RPA 407-B

SMY:

	Number
Current	0.5
10% increase	0.5
Recommended	0.7

PRIORITY: 2

SITUATION EVALUATION: Cereal starches have not been used in large volume industrial applications except for ore benefication, oil-well drilling fluids and textiles. In aluminum ore refining, starch and corn flour have been used somewhat interchangeably at the rate of about 32 pounds per ton of aluminum. Exploratory studies have indicated good potential of starch derivatives in refining other ores. High viscosity and stable additives are required for secondary oil recovery fluids. A number of starch-derived chemicals show good possibilities for this use. At one time starch was the principle sizing for warp yarns. It still is a big outlet but faces problems in disposal because its high Biochemical Oxygen Demand (BOD) leads to pollution of streams. Synthetic chemical sizes are making inroads such that industry has modified starch for this purpose

but so far with only partial success. Recent research in the Northern Utilization Research and Development Division has revealed good probability for use of starch as a reinforcing agent and accelerator in making rubber products and also in making urethane-starch plastics, resins and coating. However, additional development studies are needed.

There is good reason to believe that starch can be modified by grafting on synthetic polymers to produce flocculating agents for clarification of waste waters. Other promising opportunities for use of starch include new industrial use for high-amylose corn starch; mass production of spores grown in corn sugar media for use as a bio-insecticide to control the Japanese beetle; more economical production of amicrobial polysaccharide "xanthan" now being commercially produced and conversion of starch to alcohol for fuel.

A number of the potential benefits are difficult to estimate until sufficient preliminary data are at hand from exploratory research results. Benefits have been estimated as follows:

Starch in rubber	New use, 25 million lbs./yr.
Starch graft copolymers	New use, 40 million lbs./yr.
Starch plastics	New use, 25 million lbs./yr.
High-amylose	New use, 40 million lbs./yr.
Microbial polysaccharide (xanthan)	New use, 50 million lbs./yr.
New microbial polysaccharides	New use, 50 million lbs./yr.

OBJECTIVE: To modify cereal starches and flours by chemical and biochemical processes to obtain products with improved properties and to discover completely new applications of corn and sorghum-derived products.

RESEARCH APPROACHES:

A. Develop practical processes for the incorporation of starch, flours and their derivatives in rubber products.

B. Produce starch graft copolymers as flocculating, viscosity-improver and adhesive agents by chemically combining starch with synthetic chemicals.

C. Develop starch-derived chemicals for use in making plastics and coatings.

D. Exploit high-amylose corn starches now commercially available as textile sizes, surface-coating and film-packaging materials and adhesives.

E. Explore potential of enzymatic conversion of starches to methanol as a source of energy competitive with fuel oils.

TITLE: Conversion of corn and sorghum starches and flours into improved internal and surface-sizing agents, wet-strength agents and adhesives for the paper industry. RPA 407-C

SMY:

	Number
Current	0.1
10% increase	0.1
Recommended	0.3

PRIORITY: 3

SITUATION EVALUATION: The paper and board industry is the largest single consumer of starch and starch products in the U.S., requiring over one billion pounds annually. Starch as such and in its modified forms is used as an internal size, an external surface size and adhesive in coating paper with clay and other pigments and as an adhesive in making paper boxes.

Synthetic resins and other polymers have come into use on paper products because of their resistance to water and moisture or advantages in application. Synthetics have usually commanded higher prices than starch. In some cases their cost per unit of paper product is nearing that of starch because, per unit weight, they are more effective. The problem for research of cereal products in the paper industry is to introduce new or improved properties into cereal products.

The use of an effective wet-web strength cereal product applied at a 1 percent level (based on pulp) in all of the 3 million tons of newsprint produced in the U.S. per annum would require 30,000 tons of starch product and permit large savings in cost of newsprint production.

Success in developing practical conditions for use of starch xanthate to achieve wet- and dry-tensile strength increases along with resistance to moisture absorption could lead to the use of one-half million tons of starch xanthate. This is assuming an application of 2-1/2 percent addition to 20 million tons of paper.

OBJECTIVE: To provide starch and flour products that permit greater efficiency in paper products, that impart improved physical properties to paper, and that allow paper to meet more sophisticated end-use requirements.

RESEARCH APPROACHES:

A. Develop starch-based wet-web strengthening agents to permit paper, particularly newsprint, to be produced at faster rates.

B. Prepare and evaluate experimental starch graft-copolymers to determine their effectiveness in bonding together wet pulp fibers to give wet tensile strength sufficient to withstand higher machine speeds without breaking of the wet paper.

C. Conduct studies on the effect of paper machine operating variables on the ultimate dry- and wet-tensile strength and water absorption of starch xanthate-treated paper.

D. Investigate simplified and economical methods of preparing cationic starches and flours for use as internal size to improve dry tensile strength of paper.

RPA 408

QUALITY MAINTENANCE IN STORING AND MARKETING

INTRODUCTION

Maintenance of quality of field crop commodities against the inroads of molds, insects, excessive moisture, chemical changes and other quality deteriorating factors is needed to minimize cost in storage and distribution. The resources required to produce lost commodities are wasted. In addition there are serious losses in end use quality that occur as a result of physical and chemical changes in transportation and storage of crops. The consumer receives a product less attractive than need be and in the end pays for merchandise not usable.

TITLE: Detecting and measuring quality factors. RPA 408-A

SMY:

	Number
Current	1.0
10% increase	1.0
Recommended	1.5

PRIORITY: 1

SITUATION EVALUATION: Quality changes in corn, grain sorghum and millet can be of physical, chemical or microbiological origin. They result from heat damage in the drying process, high moisture content, enzymatic changes and deterioration, and moisture - heat - insect - microorganism relationships. These changes affect product maintenance, food and feed quality, product grade and consumer acceptance. Such changes can cause a decrease in market quality which is reflected by a lower grade of the final product. An additional change in quality is a loss in nutritive value. Many of the quality factors are determined by machines which are inefficient or yield results which do not accurately reflect the commercial value of the corn or grain sorghum. These include heat damage resulting from improper drying temperatures, deterioration due to high moisture content - insect - microorganism interrelationships and mechanical breakage. The results of this research should facilitate marketing transactions through more accurate description of products and more precise measurements of quality attributes.

OBJECTIVES: Determine the quality attributes of corn, grain sorghum and millet and their products. Develop techniques, instruments and machines for rapid, objective evaluation of quality.

RESEARCH APPROACHES:

A. Develop practical and objective methods of determining quality attributes of corn, grain sorghum and millet and their products.

B. Develop techniques, instruments and procedures for detecting and measuring chemical residues and other contaminants affecting quality.

C. Develop practical procedures and devices for sampling corn, grain sorghum and millet and their products.

D. Coordinate research effort with RPA's 207-G, 208-E, 308-B, 405, 406, 407 and 408.

TITLE: Maintaining quality during storage, processing and transport. RPA 408-B

SMY:

	Number
Current	1.3
10% increase	1.3
Recommended	2.5

PRIORITY: 1

SITUATION EVALUATION: Corn, grain sorghum and millet are highly susceptible to damage by stored-grain insects from the time of harvest until final use. Milled and processed corn products also suffer heavy losses. These grains are largely used for animal feed and the insect infestation tends to be overlooked. Estimates of losses and cost of control for stored-grain insects during the period 1951-1960 were more than $300 million annually for corn and about $30 million for grain sorghum, nationally. As production increases to meet greater needs for food and feed these losses also increase and ways must be found to reduce them.

Insect infestation in stored grain create a favorable environment for the growth of molds and bacteria. Recent findings show that stored-grain insects are carriers of avian leukosis, *Salmonella*, *E. coli*, and other microorganisms. Further research is needed on the relationships between stored-grain insects and microorganisms, and on ways to break chains of transmission.

The traditional uses of insecticides and fumigants against stored-grain insects involve complex and ever changing situations. For example, alternate materials must be found as resistance develops to those in use. Each new insecticide requires extensive evaluation of effectiveness, residues and mammalian toxicity. Therefore, research must continue on the development of safer, more effective conventional insecticidal control measures. It is also appropriate to give increased emphasis to the development of biological and physical control methods that will avoid the hazards of toxicity and chemical residues.

As a foundation for developing improved control measures, it is necessary to obtain more detailed information about the insects themselves. There are about 15 species that are responsible for most of the damage to stored grain and grain products. There are significant gaps in knowledge about the biology, ecology, physiology and behavior of these insects. Adequate progress on developing new control measures cannot be made in the absence of increased basic research along the above lines.

Based on projected increases in production for 1980, a reduction of insect losses by one-half would bring about a savings of more than $300 million annually for the nation and a proportional saving in the Southern Region.

OBJECTIVE: To develop improved measures for controlling insects and microorganisms that attack stored corn, grain sorghum and millet by the use of procedures that are effective; safe and economical; to determine optimum environmental conditions for the storing and handling of corn, grain sorghum and millet and their products during marketing; and to evaluate the economic benefits and costs of quality measurement and maintenance.

RESEARCH APPROACHES:

A. Investigate the biology, ecology, physiology and behavior of insects and of microorganisms that attack corn, grain sorghum and millet as a foundation for applied research.

B. Investigate the relationships between insects and microorganisms in stored corn, grain sorghum and millet.

C. Investigate the influence of one microorganism on another under different exacting environmental conditions.

D. Develop improved, safe, economical conventional control procedures for insects and microorganisms that leave a minimum of chemical residues.

E. Develop biological and physical control measures for insects and microorganisms that will avoid residues.

F. Develop methods of determining physiological deterioration of corn and grain sorghum and study the extent of this type of deterioration under different environmental conditions.

G. Study the economic gains associated with the reduction of quality losses in the corn and grain sorghum markets.

H. Measure the costs involved in securing these gains.

I. Evaluate the net benefits to producers, handlers and users.

J. Coordinate these research studies with those under RPA's 207-G, 208-E, 308-B, 405, 406, 407 and 408.

RPA 503

EFFICIENCY IN MARKETING AGRICULTURAL PRODUCTS

INTRODUCTION

Efficiency in marketing implies that products move from producers to processors to consumers with the maximum speed and technical efficiency consistent with low marketing costs and margins. Consequently, research in this general area for corn, grain sorghum and millet focuses on two major categories. The first is the development and technical evaluation of marketing methods, systems and equipment for handling and transport of these grains. The second is economic evaluation of the markets themselves including the costs and returns associated with various marketing methods, systems and locational patterns of both production and utilization.

TITLE: Development and evaluation of improved methods, equipment, and systems for handling grain in the marketing channels. RPA 503-A

SMY:

	Number
Current	0.8
10% increase	0.8
Recommended	1.5

PRIORITY: 1

SITUATION EVALUATION: Enormous quantities of the corn and sorghum grains produced in the Southern Region are sold off the farm and move through at least one grain elevator or marketing facility. Export grain moves through at least five or six facilities and must be handled many times. New types of large capacity transport equipment require high grain handling rates, and under current conditions grain breakage is often increased. Research is needed to develop and evaluate design criteria for grain handling equipment that minimizes physical damage, particularly to corn.

Corn and grain sorghum continue to be harvested at high moistures and fast rates. This, together with the increase in the amount of grain moving to market at harvest time, taxes conventional drying and conditioning systems. The pressing need is for more and better drying equipment and techniques, as well as improvements in handling and receiving corn and grain sorghum. Research is needed to design criteria for improved equipment and techniques.

The requirements of high-volume handling equipment also necessitates further study of rheological, physical, optical and electrical properties of corn and grain sorghum. From these studies, fundamental theories must be formulated for the development of new design criteria to minimize product damage.

Although losses have been reduced by transporting corn and grain sorghum in covered hopper-type rail cars, research is needed to reduce costs and losses when more conventional transport equipment is used. Seasonal peak demands in grain movement require better utilization of rail and highway equipment.

Benefits from research would be less expensive feed and food grain through reduced costs for physical marketing activities and reduced physical loss in the product during storing, handling and transport. Maintenance of product quality during drying, handling and storing would be realized.

OBJECTIVE: To evaluate current technology and to develop more efficient work methods, techniques, equipment and facilities for conditioning, drying, storing, handling and transporting corn and grain sorghum in the market channels.

RESEARCH APPROACHES:

A. Develop techniques and criteria for improved equipment to condition or dry corn, grain sorghum and millet.

B. Develop criteria for modifying equipment to minimize physical damage of corn, grain sorghum and millet.

C. Determine rheological, physical, optical and electrical properties of corn, grain sorghum and millet.

D. Develop improved handling methods for receiving and shipping grain at market facilities.

E. Develop design criteria for improved storages and equipment to provide recommended storage environments.

F. Evaluate existing transportation practices and equipment to determine product loss and damage, transport and maintenance costs with potentials for cost reduction.

G. Develop improved scheduling methods to increase utilization of transport equipment for seasonal peak demands.

H. Coordinate research studies with those in RPA's 208-A, 308-B and 408-B.

TITLE: Analysis of economic structure, behavior, and performance in markets. RPA 503-B

SMY:

	Number
Current	0.0
10% increase	0.0
Recommended	0.5

PRIORITY: 2

SITUATION EVALUATION: Both the actual volume and the proportion of total corn and grain sorghum production moving through the marketing system is increasing. Exports of feed grains have expanded at a faster rate than production in recent years. Significant adjustments are occurring in the location of feed grain production, in the location and size of livestock production and feeding enterprises, and in the technology of producing, harvesting, handling, transporting and marketing feed grains and related products. Federal programs continue to exert a major influence on the production, carryover, and prices of the major feed grains.

Economic analysis on the changing marketing system for corn, grain sorghums and millet will be extremely beneficial in the planning and execution of federal agricultural policy and programs, in the evaluation of current and future shifts in the character and location of production and marketing functions in both feed grains and livestock and the impact of these changes on farm and nonfarm income and profits.

OBJECTIVE: To analyze the economic structure, behavior and performance of the markets for corn, grain sorghum and millet - with special emphasis on the costs of providing required marketing services, the interregional relationships in production and marketing, the economic linkages with the livestock and commercial feed sectors and the performance of export marketing functions.

RESEARCH APPROACHES:

A. Evaluate the overall structure and performance of corn, grain sorghum and millet markets including studies of market prices, costs, margins, practices and facilities.

B. Revise the market grading standards for corn, sorghum and millet.

C. Examine the economic impacts of new and improved production and marketing technology on domestic and foreign markets.

D. Study and evaluate the economic impacts of ongoing and potential interregional shifts in the production of feed grains in relation to changes in the location and character of livestock production and marketing.

E. Coordinate the research in this area with the work undertaken in RPA 309.

NOTE: Research approach B was included here and no RPA 501-Grades and Standards were put in the report. The 0.4 SMY from 1973 inventory was included in RPA 503-B.

Table 5. Summary Table Showing Allocation of Scientist Man-Year (SMY) to Research Problem Area (RPA) Under Different Levels of Funding.

RPA		1973 Allocation		Proposed Allocation	
Name	No.	National	Southern Region	With 10% Increase	To Solve Problem Within 10 Years
Control of Insects	207	55.9	22.7	23.7	34.0
Host plant resistance	207-A		5.7	6.0	7.5
Economic injury levels	207-B		2.0	2.5	4.5
Biological control	207-C		5.0	5.0	7.0
Biology, taxonomy, physiology	207-D		5.0	5.0	7.0
Cultural practices	207-E		0.5	0.5	0.8
Non-Insecticidal manipulators	207-F		2.0	2.2	4.2
Insecticidal control	207-G		2.5	2.5	3.0
Control of Diseases	208	54.7	18.2	22.2	32.0
Identification, etiology	208-A		4.2	5.0	8.5
Genetics of plant-pathogen	208-B		5.0	6.0	8.0
Nature of disease resistance	208-C		4.0	4.2	6.5
Control by pesticides and manage	208-D		3.0	4.0	6.0
Storage diseases	208-E		2.0	3.0	3.0
Control of Weeds	209	18.8	4.1	6.1	10.0
Develop management systems	209-A		1.3	2.3	3.0
Improved equipment for	209-B		0.3	1.1	1.5
Improve effectiveness and	209-C		0.3	0.6	1.0
Control by biological means	209-D		0.0	0.0	1.0
Comparative biology, physiology	209-E		0.7	0.7	1.2
Mechanism of herbicide action	209-F		0.4	0.4	0.8
Evaluate new herbicides	209-G		1.1	1.0	1.0
Repelling birds and pests	209-H		0.0	0.0	0.5
Biological Efficiency	307	124.7	38.0	40.0	60.0
Applying genetic principals	307-A		13.0	13.0	17.0
Reduce vulnerability	307-B		5.0	6.0	9.0
Nutrition and cultural practices	307-C		5.0	6.0	8.0
Genetics and cytogenetics	307-D		4.0	4.0	7.0
Conversion of solar energy	307-E		3.0	3.0	6.0
Studies of plant processes	307-F		4.0	4.0	6.0
Plant-water utilization	307-G		4.0	4.0	7.0
Mechanization of Production	308	14.8	2.4	2.4	4.0
Mechanization of production	308-A		1.0	1.0	2.5
Harvesting, drying and storage	308-B		1.4	1.4	1.5
Production Management Systems	309	4.1	2.2	3.2	8.0
Optimizing production systems	309-A		1.7	2.0	4.0
Evaluating technology	309-B		0.5	1.0	2.0
Equilibria	309-C		0.0	0.2	2.0
Crops with Improved Acceptability	405	8.6	2.5	2.5	5.0
New and Improved Food Products	406	23.1	1.7	1.7	3.0

Table 5. (Continued)

RPA Name	No.	1973 Allocation National	Southern Region	Proposed Allocation With 10% Increase	To Solve Problem Within 10 Years
New and Improved Feed-Industrial	407	28.9	1.1	1.1	2.0
Palatability and nutritional	407-A		0.5	0.5	0.1
New starch products	407-B		0.5	0.5	0.7
Sizing, wet-strength paper	407-C		0.1	0.1	0.3
Quality Maintenance	408	15.3	2.3	2.3	4.0
Detecting and measuring	408-A		1.0	1.0	1.5
Maintaining quality	408-B		1.3	1.3	2.5
Marketing Efficiency	503	7.3	0.8	0.8	2.0
Handling grain	503-A		0.8	0.8	1.5
Analysis of markets	503-B		0.0	0.0	0.5